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Estimates of Solid Waste Buried in 100 Area Burial Grounds

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ESTIMATES OF SOLID WASTE BURIED IN THE 100 AREA BURIAL GROUNDS

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ABSTRACT

Previous estimates of radionuclide inventory and hazardous materials were based on extrapolations using limited historical burial records. The estimates in this report are based on the review of historical documents, on reconstruction of operating practices, and on the experiences of knowledgeable individuals involved in the disposal of wastes generated during the years of reactor operations.

The major radioactive wastes in the burial grounds are 375 tons of aluminum spacers, 1,103 tons of lead-cadmium pieces, boron splines (62.5 tons aluminum and 8.5 tons boron), carbon materials (2,300 lb graphite and 13,200 lb desiccant), 266 tons of aluminum process tubes, and 259 tons of lead. A total of 159.2 tons of miscellaneous waste includes gunbarrels, thimbles, control rods, nozzles, pigtails, and cadmium sheets.

Radionuclide inventories were calculated from the volume of each type of waste. The major contributors to the inventory numbers are tritium (hydrogen-3), carbon-14, cobalt-60, nickel-63, strontium-90, cesium-137, and europium-152 and -154.

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ESTIMATES OF SOLID WASTE BURIED IN 100 AREA BURIAL GROUNDS

SUMMARY

In the 100 Areas of the Hanford Site, direct land burial was used to dispose of solid, low-level radioactive wastes associated with reactor operations. From 1944 through 1973 the waste was buried in 28 locations which have been identified as burial grounds.

The information in this report is designed to support future decommissioning plans, to provide information for assessing compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program, and to update the Hanford Site Waste Inventory Data System.

Mercury was used in manometers and other instruments in the 100 Areas. Since these instruments were broken occasionally, it is a good assumption that mercury was either buried or drained to a crib or trench in the area. However, it is expected that the amount of mercury would be no more than found in any other industrial plant and is not addressed further in this report. Mercury used in the tritium separation process performed in 100 B/C Area is included in Section 5.1 of this document.

Small amounts of additional waste from special programs include equipment and materials from tritium separation lines, steam generator tubes and zirconium waste from N Reactor, sawdust and animal waste, boron steel balls, and desiccant (silica gel). Materials represented are lithium-aluminum alloy, mercury, lead, aluminum, palladium, and stainless steel, as well as a typical reactor-type spectrum of radionuclides.

No attempt is made to quantify extraneous waste such as scrap lumber, used lubricating oil, etc., which was buried in some of the burial grounds described in this document.

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to identify the radioactive solid waste burial grounds in the 100 Areas of the Hanford Site and update the previous estimates of the radionuclide and hazardous material inventories buried in them. The information in this report will be used to support future decommissioning plans and to enable the assessment of the environmental impact of the Burial Grounds by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program (Reference 1). These estimates will also be used to update the Waste Inventory Data System (WIDS).

1.2 SCOPE

The scope of this document includes only those burial grounds in the Hanford 100 Areas used to dispose of solid radioactive wastes. All these burial grounds are now inactive. The liquid disposal sites and nonradioactive solid waste sites are not addressed in this report. The data presented here were taken from existing sources and examined by knowledgeable individuals for accuracy, and summarized to provide current inventory estimates. No new sampling was conducted to support this report.

1.3 CONTENTS OF REPORT

This report is presented in eight sections. The identification numbers and locations of the primary burial grounds are presented in Section 2. The methods and assumptions for deriving the hazardous and radionuclide inventories in the seven primary burial grounds are presented in Section 3. Section 4 provides detailed information about the specific materials and the calculations used to estimate the volumes. Special program waste sites and the other small burial sites are identified, located, and the inventories summarized in Sections 5 and 6. The findings of this document are summarized in the tables presented in Section 7. Section 8 is a list of references used to compile this document. Materials presented in the appendices include an annotated list of burial grounds (Appendix A), tables of radionuclides as they are apportioned to waste volumes in the seven primary burial grounds (Appendix B), a list of individuals who contributed information used to compile this document (Appendix C), letters discussing material buried in 118-F-5 and 118-F-6 in 100-F Area (Appendix D), and a glossary of reactor equipment terms (Appendix E).

1.4 BACKGROUND

Direct land burial was used in the Hanford 100 Area to dispose of low-level, solid radioactive waste associated with reactor operations from 1944 through 1973. A total of 28 locations within the 100 Areas have been identified as inactive radioactive solid waste burial grounds. The majority of waste generated from routine reactor operations was placed in seven primary burial grounds, one for KE-KW and one associated with each of the remaining six reactors. The other burial grounds were associated with special programs such as retention basin repair and effluent line modifications, thimble removal, and special irradiations. In general, the inventories from the special programs burial grounds are included in the seven primary burial grounds because historical records do not allow a more refined breakdown. Exceptions to this are the 105-C Ball Storage Tank (118-C-2), the 115-F Desiccant Pit (118-F-4), 118-H-2 Burial Ground, and three additional burial sites for which separate estimates are provided. Two of these additional sites, the Battelle Pacific Northwest Laboratories (PNL) Sawdust Repository (118-F-5) and the PNL Solid Waste Burial Ground (118-F-6), were controlled and used by PNL for disposal of waste generated by their biological research facilities in the 100-F Area. The third site is the 108-B Solid Waste Burial Site (118-B-6) used for disposal of waste generated in the pilot tritium separation program which was housed in the 108-B Building. For the purpose of retaining identification of the Burial Grounds, for which individual inventories could not be quantified as contaminated sites, each was arbitrarily assigned an inventory of one curie of cobalt-60.

Previous estimates of waste in the 100 Area burial grounds were based on extrapolations using limited historical burial records. The 105-B Burial Ground (118-B-1) was sampled in 1977 to look for possible migration from the trenches. The results of this sampling did not reveal a practical method of characterizing the burial ground inventories either by surface mapping or by drilling techniques (Reference 2). The estimates in this report are based on the review of historical documents, on reconstruction of operating practices, and on the experiences of knowledgeable individuals involved in the disposal of wastes generated during the years of reactor operation.

2.0 DESCRIPTION AND LOCATION OF SOLID WASTE BURIAL GROUNDS

There is a total of 28 different sites identified as radioactive solid waste burial grounds in the Hanford 100 Areas. Seven of these sites specifically supported reactor operation and are considered the primary burial grounds for their respective reactors. Three other sites served specific programs such as the tritium separation program at 100-B and biological studies at 100-F. These three sites (118-B-6, 118-F-5, and 118-F-6) are characterized separately in this report in Section 5. Three additional burial sites at 100-C, 100-F and 100-H (118-C-2, 118-F-4, and 118-H-2) are addressed separately in Section 6. These are small burial sites with individual waste volumes and inventories that could be estimated since they received only one specific type of waste. The remaining 15 burial sites resulted from reactor upgrade projects, major maintenance projects, and special irradiations programs. The contaminated waste deposited in these "special" burial grounds, for the most part, contained very low levels of radioactivity. Some exceptions include vertical and horizontal rod thimbles and rods. The inventory for these items is included in the primary burial ground summary since historical documentation did not allow accurate apportionment to individual sites. A complete listing of the burial grounds and their contents is included in Appendix A.

The seven primary burial ground sites are identified as follows:

- 118-B-1 - 105-B Reactor
- 118-C-1 - 105-C Reactor
- 118-D-2 - 105-D Reactor
- 118-D-3 - 105-DR Reactor
- 118-F-1 - 105-F Reactor
- 118-H-1 - 105-H Reactor
- 118-K-1 - 105-KE and KW Reactors

3.0 PRIMARY BURIAL GROUNDS WASTE VOLUME AND RADIONUCLIDE INVENTORY

The majority of waste generated from routine reactor operation was placed in seven primary burial grounds, one for KE-KW and one associated with each of the remaining six reactors.

3.1 GENERAL ASSUMPTIONS USED TO ESTIMATE WASTE VOLUMES AND RADIONUCLIDE INVENTORIES

3.1.1 Waste Volumes

- The quantity of waste generated is a function of the total years each reactor operated, taking into consideration special production programs and major maintenance, repair, and reactor upgrade programs that involved burial of discarded reactor components. The total time the reactors were operated from initial startup to shutdown for deactivation is 142 reactor-years. A time-operated efficiency of 80% or 113.6 reactor-years was used to calculate the waste generated.
- Pertinent information was gathered from experienced long-service employes, inventories of materials on hand at the respective reactors, and historical data from company documents.
- The major radioactive wastes are aluminum spacers, lead-cadmium reactor poison* pieces, boron splines, graphite, process tubes, and lead. Of lesser quantities are gunbarrels, thimbles, control rods, nozzles, pigtails, and cadmium sheets. A description of each of these materials and the methods and assumptions used to calculate an inventory for each are found in Section 4.0.
- Other solid waste generated in relatively small quantities is considered in the inventory of soft waste. However, 3X balls sorted from the "Hot Ball" sorter at 105-C and disposed of in the 105-C Ball Storage Tank (118-C-2) and desiccant disposed in the 115-F Pit (118-F-4) are considered separately in Section 6.0.
- Solutions used to decontaminate internal and external components of the reactor were contained in the liquid waste systems and were not disposed of in the solid waste burial grounds.

3.1.2 Radionuclide Inventory

- The estimated quantity of each type of material was used to calculate the radionuclide inventory of the material.
- Ninety percent of all splines were in the reactors for a period of one day. Ten percent were in the reactors for thirty days.
- Ninety percent of lead-cadmium pieces were in the reactors for a period of one day. Ten percent were in the reactors for thirty days.

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*In this report, poison is defined as any nonfissionable element in a reactor with appreciable neutron absorption cross-section.

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- The radionuclide concentrations for graphite dust were obtained from Reference 3 (UNI-3714 Rev. 1, Radionuclide Inventory and Source Terms for the Surplus Production Reactors at Hanford).
- Process tube radionuclide inventories were based on data from Reference 3 and corrected to account for the tube replacement program. The nickel content in the aluminum process tubes was assumed to be 0.01 percent maximum.
- Spacers were assumed to have the same corrosion film radionuclide concentration as the process tubes. Each spacer is assumed to have 2 grams of corrosion film.
- All activation calculations assume a thermal flux of 5×10^{13} neutrons per cm^2-sec in the active zone of the reactor. For the reflector zone, a thermal flux of 5×10^{12} neutrons per cm^2-sec is used. The fast flux is a factor of 100 less than the thermal flux.
- All inventories are decay corrected to June 1, 1987.
- The irradiation time for spacers was six weeks.

3.2 METHOD OF APPORTIONING WASTE TO SPECIFIC BURIAL SITES/REACTORS

The breakdown of waste by reactor was obtained by calculating a percentage for each reactor derived from its operating time relative to the total reactor-years all reactors operated. Table 1 gives the operating history of the reactors.

TABLE 1. Reactor Operating Histories

Reactor Facility	Initial Startup Date	Final Shutdown Date	Years Operated*
B	09/26/44	02/13/68	22**
C	11/18/52	04/25/69	17
D	12/17/44	06/26/67	23
DR	10/03/50	12/30/64	14
F	02/25/45	06/25/65	20
H	10/29/49	04/21/65	16
KE	04/17/55	01/28/71	16
KW	01/04/55	02/01/70	15

*Rounded off to years.
**B Reactor was shut down and held in standby status from 03/19/46 to 06/02/48, then restarted and operated until February 1968.

Special consideration was given to known differences in operating levels and special production programs. The percentages of material type assigned to each reactor are shown in Table 2.

TABLE 2. Material Allocation Percentages

	Reactor %						
Material Type	B	C	D	DR	F	H	KE/KW
Spacers	13	12	12	10	10	10	33
Lead-Cadmium Poison Pieces	19	10	21	13	21	14	2
Splines	15	13	15	11	14	11	21
Graphite - Broaching	13	10	13	10	12	9	33
- Overbore	0	100	0	0	0	0	0

Inventories of material not appearing in Table 2 were calculated from other factors. The number of aluminum tubes was available from historical documents. Desiccant volumes were calculated from the number of driers located at each reactor and the volume of silica gel in each drier. The lead was equally distributed among the seven burial grounds, except for an extra 6 tons at 100-K used at the 1706-KE Test Facility, 86 tons used in the shipping and handling casks buried at 100-D, and the amount generated during the tritium separations (P-10) program buried at 100-B (118-B-1 and 118-B-6 Burial Grounds).

The distribution of the following miscellaneous material was determined in accordance with the characteristics and history of the reactors:

- Equal numbers of rod channel thimbles were disposed of at B, D, DR, F and H. C and KE/KW did not have rod thimbles. While H had more rod channels than B, D, DR and F, the H reactor was newer and did not replace as many thimbles for routine maintenance purposes. All thimbles were removed in 1952 when modifications were made to the 3X safety system.

- Equal numbers of gunbarrels were disposed of at each reactor, except at C reactor where an additional 80 gunbarrels were disposed of as a result of a channel overbore program of a 40-tube block piloted at 105-C.

- In calculating the number of vertical safety and horizontal control rods disposed of from each reactor, it is assumed that one-half the vertical safety rods were replaced during the operating history and that the horizontal control rods were replaced two times at each reactor. The variations in the quantity of rods disposed of in each burial ground reflect the difference in the number of rods installed at the reactors.

- All inlet nozzles were replaced on all reactors except KE and KW during a project to increase coolant flow. The number replaced at KE and KW was incidental to routine maintenance. Also, there were nozzles replaced at the other reactors for maintenance purposes. These have been included as stated in the calculations.
- All front and rear pigtails were replaced on all reactors at least twice during their operating history.

4.0 MATERIAL DESCRIPTIONS AND ESTIMATES

4.1 ALUMINUM SPACERS

The estimate of spacers used at the eight deactivated 100 Area reactors is 1,700,000 or the equivalent of 425 tons of aluminum.

4.1.1 Description of Spacers

Spacers were used to center the reactor fuel column in the process tube and to prevent the fuel elements from flushing to the rear cap closure during high flow (operating) periods. The spacers were 8-in. long with an outside diameter of 1.4-in, and a 0.25-in. wall thickness. Cylindrical in shape, the spacers had a number of perforations along the axis. The spacers were made from 2S grade aluminum, 6063 T6 Alloy consisting of the elements shown in Table 3.

TABLE 3. Composition of Spacers

Element	Percentage
Al	97.5
Si	0.2 to 0.6
Fe	0.35
Co	0.001
Mg	0.10
Mn	0.45 to 0.9
Cr	0.10
Zn	0.10
Ti	0.15
Ni	0.01

4.1.2 Assumptions Used to Arrive at Estimate

- A total of 13 spacers was used to position the fuel in each process tube charge.
- An average of 275 fuel charges was processed through each reactor each month.
- Out of the 13 spacers in each process tube, four were not recoverable because of high dose rates from induced radiation and were buried as waste.
- The total reactor-years of operation was 113.6 (based on time operated efficiency of 80%).

- There were two types of spacers designed to facilitate remote spacer sorting. The "expendable" spacers were charged adjacent to the fuel column and constitute the bulk of the spacers discarded because of induced radiation. The weight of an "expendable" spacer is 0.5 lb. The "regular" spacers were recoverable.

- The reactors were shut down and their systems deactivated over a period of seven years. As the first reactors were deactivated, the recoverable spacers were transferred to an operating reactor. Consequently, only six complete reactor loads of spacers were considered on hand when the final reactor was deactivated. For the purpose of this estimate, three complete reactor loads for a 2004-tube reactor and three for a 3220-tube reactor were used in the calculation.

4.1.3 Calculation of Waste Estimate

- Total tubes processed in one reactor year (275 x 12) = 3,300

- Total tubes processed during 113.6 reactor-years (3300 x 113.6) = 374,880

- Spacers disposed of during operating period (4 x 374,880) = 1,499,520

- Inventory of spacers at end of operation (2004 x 3) + (3220 x 3) x 13 = 203,736

- Total spacers disposed of in 100 Area Burial Grounds (203,736 + 1,499,520) = 1,703,256

- Total tons of spacers buried (1,703,256 x 0.5 lb per spacer) ÷ 2000 = 425

- Total tons of irradiated spacers buried (1,703,256 - 203,736 x 0.5 lb) ÷ 2000 = 375

NOTE: (1) Spacers were used in various production tests and special programs that were not considered in the above calculation. However, during the early operation of B, D, and F, a 275-tube discharge would occur about every three months. The two conditions are considered to be off-setting.

(2) The inventory of 203,736 spacers at the end of the operating period should not be included in the radionuclide inventory because the ending inventory was not activated.

4.1.4 Radionuclide Inventory for Spacers

From the list of elements given in Table 3 for the composition of the spacers only iron, nickel, and cobalt are of interest for radionuclide inventory estimates. Nuclides formed by neutron activation of the remaining elements are either stable or have such short half-lives that the radionuclides have decayed to zero.

Iron-54, which constitutes 5.8 percent of natural iron, undergoes a transformation to iron-53 by an (n,2n) reaction with high-energy neutrons. The iron-53 decays by positron emission within a few minutes to form manganese-53 with a half-life of 3.7×10^6 years.

A conservative estimate of the amount of manganese-53 produced in the spacers was made by using the fast flux in the reflector zone and assuming the resonance integral represents the capture cross-section for the (n,2n) reaction. The activation analysis yields a value of 3×10^{-5} curies for the total production of manganese-53 for all eight production reactors.

The calculation of the cobalt-60 inventory is complicated by the relatively short half-life (5.27 years) and the different final shutdown dates for the reactors. Each reactor was calculated separately and all cobalt-60 produced prior to 1950 was considered negligible. The amount of cobalt-60 produced per reactor per year using the throughput values for spacers given in Section 4.1.3 was calculated to be 0.22 curies. Decay correcting from the year that the cobalt-60 was produced to June 1987 and summing the decay corrected production over the operating years of the specific reactor, produced values ranging from 0.01 curies at DR to 0.03 for KE/KW.

The cobalt-60 estimated inventory for each of the burial grounds is included in Table 10 and in the tables in Appendix B. The Ni-63 and Ni-59 calculated inventory is very small.

4.2 LEAD-CADMIUM POISON PIECES

The estimate of lead-cadmium used as "reactor poison" and disposed of in the burial grounds in the 100 Areas is 1,103 tons, of which 1,059 tons are lead and 44 tons are cadmium.

4.2.1 Description of Lead Cadmium Element

The lead-cadmium (Pb-Cd) alloy used as reactor poison was in the form of a solid rod approximately 1.4 in. in diameter and 6 in. long. The rod was sealed in an aluminum can with a wall thickness of 0.035 in. A total of 38 canned pieces was laid end-to-end to form a process tube column of poison. The word "poison" was used to describe the high neutron-absorbing characteristics of the column. Each piece weighed 3.36 lb. The alloy was composed of the elements shown in Table 4.

4.2.2 Assumptions Used to Arrive at Estimate

Lead-cadmium pieces functioned either as supplemental control during reactor startup and operation or as total control during extended outages.

From 1944 through 1960, lead-cadmium pieces were the primary supplemental control device used during reactor startups to override the reactivity transients. Following 1960 when boron splines were introduced as supplemental poison, only six or seven lead-cadmium columns in addition to boron splines were used in B, C, D, DR, F and H reactors for startup poison.

TABLE 4. Composition of Lead-Cadmium

Element	Percentage
Pb	95.88
Cd	3 to 4
Ag	0.02
Ba	0.001
Cu	0.08
Zn	0.001
Fe	0.002
Bi	0.005
Sn and Sb + As	0.002

All reactors used lead cadmium for total control throughout reactor life to ensure that the reactor remained subcritical with zero xenon during extended outages. The recovery rate for reuse of total control lead-cadmium was about 90%.

In order to develop some backup information to support the estimates of lead-cadmium buried, a search of available historical records was made. The record search produced "spotty" and incomplete information. The information obtained is summarized in the following paragraphs:

Records Center

- Government regulations required documentation by Special Memorandum on the disposal of any government property. Lead-cadmium poison pieces were included in the list of property to receive this special documentation. Searching the files produced Special Memorandums for process material buried in 1948 and 1949. The records showed 72.7 tons of lead-cadmium buried in 1948 and 60.7 tons in 1949. During these two years there were three reactors contributing an average burial rate of 22.2 tons of lead-cadmium per reactor-year. There were 69.7 reactor operating years between 1945 and 1960 when splines replaced lead-cadmium for startup. Multiplying 22.2 tons by 69.7 reactor-years yields a total of 1,547 tons of lead-cadmium buried. However, it is felt that this estimate is high because in the early stages of operation from 1944 to 1948, the recovery rate for reusable lead-cadmium was low which would tend to make the burial rate high. Also, there was no set schedule for burying lead-cadmium. The burial rate in 1948 and 1949 could have been influenced by the cleanup of a backlog inventory.

- Monthly record reports for the years of 1948 through 1959 were reviewed to establish the number of lead-cadmium pieces produced during that period. The format for reporting production statistics changed from year

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to year and there were only six of the eleven years which showed lead-cadmium being produced. The total number of pieces listed as produced during the period was 86,170 pieces or 144.8 tons, an average of 24.1 tons per calendar year. Assuming there were 20 calendar years in which 24.1 tons of lead-cadmium pieces were produced, there would be 482 tons buried in the 100 Area burial grounds.

Burial Ground Logbooks

- 100-F Area. Two logbooks have been located that contain burial records of waste buried in 100-F Area. The first burial entry in one logbook is 9/22/60 and the last entry is 8/2/63. The second logbook has an initial burial entry of 8/1/63 and a final entry of 7/20/65. All months included between 9/22/60 and 7/20/65 showed burial activity. There is only one burial entry that showed lead-cadmium. A total of 840 lb is listed as being buried on 8/1/61. It should be noted that the dates included in this review were after poison splines replaced lead-cadmium pieces so the amount of lead-cadmium waste is expected to be low in the period covered.

- 100-B Area. There are three separate listings of burial activities at 100-B covering a period of 3/2/45 through 11/1/65. One listing covers a period of 3/2/45 through 11/46, the second listing is 9/46 through 3/63 and the third is from 9/60 through 11/65. The listings showed burial activities in each of the years covered in the respective listings. A total of 77 tons of lead-cadmium was listed as buried in the combined listings.

From the above information it is evident that the supportive documentation is inconclusive for the amount of lead-cadmium buried. Therefore, the following assumptions are used to estimate the amount of lead-cadmium in the 100 Area burial grounds.

- The total reactor-years of operation was 113.6.
  - 11 reactor-years of operation before reuse of recoverable lead-cadmium
  - 58.7 reactor-years of operation using recovered and new lead-cadmium
  - 43.9 reactor-years of operation using lead-cadmium primarily for total control

- Reactor startups requiring lead-cadmium to override reactivity transient on startups averaged 1.5 per month per reactor.

- Extended outages requiring lead-cadmium to meet total control requirements occurred eight times a year for 43.9 reactor operating years.

- Total columns of lead-cadmium used per startup averaged 25.

- There were 38 pieces of lead-cadmium in each column.

- Reuse of recoverable lead-cadmium was started in about 1948.

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- Lead-cadmium was used exclusively for supplemental control until 1960. From 1960 to final shutdown, lead-cadmium was used to meet total control on extended outages and splines were used for startup supplemental control.

- Residence time of lead-cadmium in the reactor for startup control was about four hours. The material was cycled through the reactor a maximum of three times before physical damage to the pieces made them unsuitable for reuse.

- From 1960 through final shutdown, an average of 48 columns of lead-cadmium was required on extended outages to meet total control requirements.

- The average disposal rate of lead-cadmium for supplemental control was 40%.

- The average disposal rate for lead-cadmium used for total control was 10%.

- The final inventory of lead-cadmium on hand at deactivation of the last reactor (105-KE, 1971) was four loadings (4 x 25 x 38).

4.2.3 Calculations

- Before lead-cadmium recovery (1944 to 1948)
  11 years x 12 mo = 132 mo
  1.5 startups per mo = (132 x 1.5) = 198 startups
  198 x 25 columns x 38 pc/column = 188,100 lead cadmium pc
  188,100 x 3.36 lb/pc = 632,010 lb
  632,000 lb ÷ 2,000 lb per ton = 316 tons

- From 1948 through 1959 (60% lead-cadmium recovery rate period)
  58.7 years x 12 mo = 704.4 mo
  704.4 x 1.5 startups per mo = 1,056 startups
  1,056 x 25 columns/startup = 26,415 columns
  26,415 x 38 pc/column = 1,003,770 pc
  1,003,770 pc x 3.36 lb/pc = 3,372,667 lb
  3,372,667 lb ÷ 2,000 lb per ton = 1,686 tons x 40% burial rate = 674 tons

- Total control lead-cadmium
  43.9 years x 8 extended outages per year = 351.2 extended outages
  351.2 x 48 columns = 16,857 columns
  16,857 x 38 pc/column = 640,588 pc
  640,588 pc x 3.36 lb/pc = 2,152,378 lb
  2,152,378 lb x 10% burial rate = 215,237 lb
  215,237 lb ÷ 2,000 lb per ton = 107 tons

- Ending inventory following final shutdown
  100 columns x 38 pc = 3,800 pc
  3,800 x 3.36 lb = 12,768 lb
  12,768 lb ÷ 2,000 lb per ton = 6 tons

- Total lead-cadmium buried = 316 + 674 + 107 + 6 = 1,103 tons.
- Total lead buried = 1,103 tons x 0.96% = 1,059 tons
- Total cadmium buried = 1,103 tons x 0.04% = 44 tons

4.2.4 Radionuclide Inventory for Lead-Cadmium Elements

The radionuclide inventory estimates for the burial grounds from lead-cadmium (Pb-Cd) elements were based on the throughputs stated above and the composition of the Pb-Cd listed in Table 4. In addition to the Pb-Cd composition, the cladding composition was assumed to be the same as the 2S aluminum listed in Table 3.

Within the Pb-Cd, the only nuclides of interest are the silver (Ag) and the barium (Ba). Other elements within the Pb-Cd either form stable nuclides when irradiated or are of such small quantities or of such short half-lives to be negligible. The aluminum cladding contains natural cobalt, hence does provide a source of Co-60 to the burial grounds.

The calculated inventories of Ag-108m, Co-60, and Ba-133 from irradiation of the Pb-Cd elements are shown in the summary Tables 7 and 10 and in Appendix B for each burial ground.

4.3 SPLINES

The estimate of boron splines used and disposed of in the 100 Area solid waste burial grounds is 142,236 splines composed of 62.5 tons of aluminum and 8.5 tons of boron.

4.3.1 Description of Boron Splines

Splines were used in the reactor to assist in control of the reactivity transient during startup and to "flatten" the neutron flux distribution for optimum production. Special caps were installed on the inlet nozzles of selected process tubes so that splines could be inserted and withdrawn during reactor operation. Wide-scale use of the splines in the Hanford reactors started in 1960. The majority of splines used were about 1/2 in. wide, 1/16 in. thick, and 30 ft long. The splines were made of a combination of 12 $\pm$ 1.5% boron and 88% type 1100 aluminum.

4.3.2 Assumptions Used to Arrive at Estimate

- An average of 180 splines was used for startup and "flattening" after each outage and during the subsequent operating period.
- There were 18 startups requiring splines for each reactor-year operated after 1960, the year when wide-scale use of splines began.
- There was a total of 43.9 reactor years of wide-scale use of splines.
- Each spline weighed about one pound.

4.3.3 Calculations

- Total extended outage startups = 43.9 x 18 = 790 startups
- Total used = 790 x 180 = 142,236
- 142,236 x 1 lb = 142,236 lb 2,000 lb per ton = 71 tons

4.3.4 Radionuclide Inventory of Splines

The only radionuclide of interest from the irradiation of splines is cobalt-60 which originates from the cobalt impurity in the aluminum. For calculation purposes, it was assumed that <u>all</u> the splines were irradiated during 1967. Assuming that all splines were irradiated in a single year (1967) introduces some error in tnat the splines used prior to 1967 will have decayed to a lower activity; and, the splines irradiated after 1967 will have slightly greater activity remaining. These two effects are judged to nearly cancel each other. The calculated inventory of Co-60 from the buried splines is included in Tables 7 and 10 and the Appendix B tables for each burial ground.

4.4 CARBON-14 SOURCES (GRAPHITE AND DESICCANT)

The estimate of material containing carbon-14, which was disposed of in the 100 Area burial grounds, includes:

. Graphite from tube replacement	1,400 lb
. Graphite from overbore program	900 lb
. Desiccant from driers in the 115 Buildings	13,200 lb

4.4.1 Description

There were two programs that resulted in a small quantity of irradiated graphite scrap which was disposed of in the burial grounds. In one program, as process tubes were replaced in the reactor, the channel was broached with a special tool to reduce the restrictions caused by graphite growth and shifting of loose graphite. A vacuum was applied to the channel during the broaching operation to collect the graphite dust. About 10 lb of graphite were emptied about once each month from the vacuum separator. In the other program, a block of 40 tube channels was overbored at 105-C reactor to demonstrate the feasibility and cost of increasing production by using larger fuel elements. The graphite waste that resulted from the overbore operation was disposed of in the 105-C burial grounds.

A second source of carbon-14 in the burial grounds is from the disposal of depleted desiccant (silica gel) used in the 115 Building drying towers in the reactor gas system.

4.4.2 Assumptions Used to Arrive at Estimate and Calculations

- Graphite from Tube Replacement
  - Only trace amounts of graphite were removed from each channel when broaching for tube replacement.
  - The number of tubes replaced was 28,000. See Section 4.5 of this report.
  - It is estimated that 50 lb of graphite were collected per 1,000 channels broached.
  - Calculation: (28,000 channels ÷ 1,000) x 50 lb = 1,400 lb
- Graphite from Channel Overbore
  - A total of 40 tubes were in the overbore program.
  - The channel inside diameters were enlarged from 1.8 in. to 2.0 in.
  - The overbore extended through the entire graphite block (28 ft).
  - The density of the graphite is 2.5 g/cm^3.
  - The 0.2-in. enlargement of the channel removed 163,900 cm^3 of graphite.
  - Calculation: 163,900 cm^3 x 2.5 g/cm^3 ÷ 453.59 g/lb = 903 lb
- Desiccant from the Gas Recirculation System
  - Each drier contained 200 ft^3 of desiccant.
  - The desiccant was replaced once in each drier during the operating history.
  - There were 22 driers in the deactivated 115 Buildings.
  - The desiccant weighs about 3 lb per ft^3.
  - Calculation: 200 ft^3 x 22 = 4,400 ft^3 x 3 lb/ft^3 = 13,200 lb ÷ 2,000 lb/ton = 6.6 tons

4.4.3 Radionuclide Inventory for Graphite

To calculate the radionuclide inventory of the graphite dust, the values presented in Reference 3, Radionuclide Inventory and Source Terms for the Surplus Production Reactors at Hanford, for the graphite stacks were scaled down by the ratio of the estimated masses. Before ratioing the radionuclide amount, a "composite" inventory was assumed by using the "worst" case, i.e., the highest values were used for each radionuclide. There were three exceptions to "composite" inventory: H-3, C-14, and Ca-41 for the K Reactors were examined separately since the stack inventories varied significantly from the other Hanford reactors.

An additional correction was made to include the overbore graphite program at C Reactor. The calculated inventory for the overbore graphite was added to the estimated inventory for normal broaching dust.

In all cases the radionuclide inventory of the graphite in the burial grounds contributes only a few curies to the total burial ground inventory. The calculated radionuclide inventory from the graphite is shown in Table 10 and in the tables in Appendix B.

4.5 PROCESS TUBES

The estimate of the number of process tubes that were disposed of in the 100 Area burial grounds is 28,000 tubes or 266 tons of aluminum.

4.5.1 Description

The process tubes, fabricated out of C-64-F aluminum alloy, were about 40 ft long with an inside diameter of 1.75 in. and a wall thickness of about 0.125 in. The tubes penetrated the reactor block horizontally with the center 25 ft located in the active zone of the reactor. The major cause for replacement was internal corrosion which started on a large scale following flow increases initiated through Project CG-558 in the mid 1950s. The life expectancy of a process tube in the central zone following CG-558 averaged about four years.

The composition of the aluminum alloy is as follows:

C-64-F Alloy

a.	Aluminum	99.30% Min.
b.	Iron	0.35-0.50%
c.	Silicon	0.17% Max.
d.	Titanium	0.05% Max.
e.	Copper	0.04% Max.
f.	Manganese	0.03% Max.
g.	Chromium	0.03% Max.
h.	Zinc	0.03% Max.
i.	Magnesium	0.01% Max.
j.	Tin	0.01% Max.
k.	Lead	0.01% Max.
l.	Bismuth	0.01% Max.
m.	Nickel	0.01% Max.
n.	Lithium	0.008% Max.
o.	Cadmium	0.003% Max.
p.	Cobalt	0.001% Max.
q.	Boron	0.001% Max.

4.5.2 Assumptions Used to Arrive at Estimate

- The total number of tubes replaced because of tube leaks was about 1,320.
- The total number of tubes replaced because of stuck charges was about 1,600. This assumes there were 1,100 fuel failures stuck and that there were 500 other charges stuck because of fuel warping.
- While the K Reactors were operating, 70% of the aluminum tubes were replaced with zirconium tubes. Records show that 2,351 tubes were replaced at KE and 2,358 tubes at KW.

- The life expectancy of the 1,000 high-corrosion-rate process tubes in 105-B, C, D, DR, F, and H reactors was four years. The tube replacement program started in 1955.
- A process tube 40 ft long weighs 19 lb. Tubes in the K Reactors weighed 3 or 4 lb more because they were slightly longer and larger in diameter. However, for simplicity, all tubes are considered to weigh the same.

4.5.3 Calculations

TABLE 5. Process Tubes Replaced

Reactor	Replacement Program	Tube Leaks	Failure from Stuck Fuel Charges
B	3,911	160	200
C	1,736	160	200
D	3,972	160	200
DR	2,649	160	200
F	4,388	200	200
H	3,702	160	200
KE	2,351	160	200
KW	2,358	160	200
	25,067	1,320	1,600

Total 1320 + 1600 + 25,067 = 28,000 (rounded number)
28,000 x 19 lb = 532,000 lb ÷ 2,000 lb per ton = 266 tons

4.5.4 Radionuclide Inventory for Process Tubes

Several years after the final shutdown of the DR reactor, samples were obtained from three process tubes. The sample analysis included both the aluminum tube material and the film layer inside the tubes. The data from the radionuclide analyses of the DR process tubes are considered the best available and were used for the estimated inventories for the burial grounds. The DR data were decay corrected to obtain the estimated radionuclide concentrations for all the process tubes in the burial grounds. A simplification was assumed that major tube replacements occurred every four years, i.e., 1955, 1959, 1963, and 1967. In reality, tube replacement was ongoing throughout the years following 1955. There were several exceptions to the four-year groupings: operation of C Reactor was not started until late 1952 so major tube replacement would not be expected as early as 1955; the only tube replacement at KE and KW reactors was in 1963 when the zircalloy tubes were installed; and DR, F, and H Reactors were no longer in operation during 1967.

The DR sample analysis did not indicate any nickel isotopes. It is not known if this omission means that the nickel isotopes were not present or that the analysis simply was not performed because of the relative high cost or because of oversight. The nickel-59 and nickel-63 inventory estimates from the process tubes were calculated using the maximum (0.01%) nickel content of C-64-F alloy that was used for process tubes.

The estimated radionuclide inventories for the process tubes are shown in Table 10 and in the table in Appendix B.

4.6 LEAD

The majority of lead buried in the 100 Area burial grounds is in five forms: standard 25-lb lead bricks; lead sheets that varied in thickness from 0.5 to 0.062 in. for special applications requiring a thin layer of shielding; lead used in shipping, handling, and shielding casks; lead wool used sparingly for special shielding application; and lead-cadmium pieces (95.88% lead) used for reactivity control. The lead-cadmium was discussed in Section 4.2 and will not be included here. Estimates of the first four forms of lead are as follows:

. Lead Bricks	161 tons
. Lead Sheets	9 tons
. Shipping, handling and shielding casks	86 tons
. Lead wool	2 tons
TOTAL	258 tons

This estimate does not include the lead that was buried during the tritium separation program in either the 118-B-6 burial ground or that contributed by the program to 118-B-1. Lead disposed of in these burial grounds by the tritium program is estimated separately.

Standard Lead Bricks

Purchasing records were destroyed in accordance with the records management control instructions or were lost through the deactivation practice of destroying records that were not considered to have operational and historical value at that time. Throughout the operating history of the 100 Area single-pass reactors, lead in a metallic form was not considered a hazardous material so it did not receive the control that is required today. Consequently, there is no recorded information available to support the numbers developed in this estimate.

Lead brick was used extensively to shield highly radioactive material for both long- and short-term storage and in the reactor experimental facilities for processing special irradiations. In about 1975 a request was made to transfer all noncontaminated lead brick to Rockwell Stores for control and dispersion. At that time there was an inventory of about 4,500 lead bricks located in the 100 Areas and all except about 500 were contaminated.

In December 1985 a second inventory was taken and 4,300 lead bricks, all in radiation zones, were found. This agrees favorably with the 1975 inventory.

Based on the ending inventory of 4,300 contaminated lead bricks and the assumption that the inventory was turned over four times during the history of single-pass reactor operation, there are approximately 12,900 contaminated lead bricks (161 tons) in the 100 Area burial grounds.

Calculation: 4,300 x 4 = 17,200 - 4,300 on hand and not buried = 12,900
12,900 x 25 lb = 322,500 lb ÷ 2,000 lb per ton = 161 tons

Lead Sheets

The lead sheets had limited application when a small amount of shielding was needed to reduce radiation dose rates. The sheets of lead were more adaptable to certain shielding configurations. There is no accurate basis for estimating how much lead sheet was buried. An inventory of lead sheet in the reactor buildings in December 1985 showed about 2,000 lb on hand. Based on operating experience, it is estimated that this inventory represents about one tenth of the total lead sheets used during the operating history of the single-pass reactors. The remainder is buried in the 100 Area burial grounds (18,000 lb ÷ 2,000 lb per ton = 9 tons).

Shipping, Handling and Shielding Casks

A number of different shipping, handling and shielding casks were used in the process of handling radioactive materials. For the purpose of this estimate, the casks have been divided in two classes: "J" metal shipping casks and miscellaneous casks. The casks were made of 2- to 4-in. lead sandwiched between stainless or other malleable steel plate constructed to the desired geometry.

- "J" Metal Casks

  There were two generations of five each "J" metal shipping casks. Each cask weighed 10 tons with about 98% of the weight being lead. Following the special programs for which they were designed, the casks were placed in a user pool and were used at various Department of Energy (DOE) sites. The "J" casks were eventually declared excess and an undetermined number were transferred to other DOE contractors. An estimated five of these casks (49 tons of lead) were buried in the 100 Area burial grounds.

- Miscellaneous Casks

  Different cask designs were used to accommodate many special irradiation programs and special problems that evolved over the years. On completion of the programs, the casks were stored in the 100 Area burial ground or on the 100-D cask pad for reuse as applicable. Approximately 150 casks accumulated and were disposed of in the burial ground at the end of the single-pass reactor operation. The majority of the casks were buried at 100-D. While the casks varied somewhat in size and weight, for the purpose of this estimate, an average weight of 500 pounds per cask is used. On this basis, the miscellaneous lead casks contributed 37 tons to the inventory of lead in the 100 Area burial grounds.

Lead Wool

A limited amount of lead wool was used for caulking and for blanket shielding. The December 1985 inventory showed less than 100 pounds on hand in the single-pass reactors. Based on operating experience, it is estimated that about 2 tons of contaminated lead wool were buried in the 100 Area burial grounds.

4.7 MISCELLANEOUS WASTE

Several different reactor components were replaced during routine maintenance and on special production improvement programs. Six types of these components, which have been included in other burial ground inventory reports, are included in the following estimates. The components included are gunbarrels, thimbles, horizontal control rods (HCRs), vertical safety rods (VSRs), nozzles/pigtails and reactor tools. A total of 145.8 tons is assigned to this category of waste. The estimated inventories are shown in Table 6.

4.7.1 Gunbarrel Assumptions

A reactor gunbarrel is similar to a Schedule 40 carbon steel pipe and measures about 2 in. in diameter and is approximately 7.6 ft long. The gunbarrel is installed at the inlet and outlet of the process tube bore in the reactor. It spans the gas plenum, thermal shield, and biological shield and extends about 14 in. beyond the outside plate of the reactor. The gunbarrel provides support for the thin aluminum process tube. It provides for a gas seal where it penetrates the outside plate and is adapted to a nozzle with a process tube access cap on the end of the nozzle to facilitate the refueling operation. Only the first several inches (10 in.) of the gunbarrel become activated. The number of gunbarrels used in the estimated quantity is based on a review of burial records at 100-B through 1963.

TABLE 6. Tons of Miscellaneous Waste

Type of Material	B	C	D	DR	F	H	KE-KW
Gunbarrel	1.0	2.0	1.0	1.0	1.0	1.0	2.0
HCR/VSR Thimbles	2.75	0	2.75	2.75	2.75	2.75	0
HCRs	0.75	1.2	0.75	0.75	0.75	1.2	3.2
VSRs	1.5	2.2	1.5	1.5	1.5	2.2	4.5
Nozzles/Pigtails	15.0	15.0	15.0	15.0	15.0	15.0	6.0
Reactor Tools	0.5	0.5	0.5	0.5	0.5	0.5	0.5
TOTALS	21.5	20.9	21.5	21.5	21.5	22.65	16.2

Calculation: Using the 100-B burial record coupled with personal experience, it is estimated that 75 gunbarrels were replaced and discarded during routine maintenance at each reactor. An additional 80 gunbarrels were replaced and discarded at 105-C as a result of the overbore feasibility study which included a block of 40 process channels.

Each gunbarrel weighs 27 lb, based on the weight of a 7.6 ft long, 2-in. Schedule 40 carbon steel pipe.

75 gunbarrels x 27 lb = 2025 lb ÷ 2000 lb per ton = 1 ton
80 gunbarrels x 27 lb = 2160 lb ÷ 2000 lb per ton = 1 ton

Only the activated portion of the gunbarrel should be included in the calculation of radionuclides. This portion would amount to 12 in. or 3.6 lb per gunbarrel.

4.7.2 HCR and VSR Thimbles Assumptions

In the early operation of the first five reactors, aluminum thimbles were used in the HCR and VSR channels to provide a sealed access to the reactor for the control and safety rods and for a boron solution used as a third shutdown device. The original design of the reactor systems provided the third shutdown device which, on demand, would release a liquid boron solution into the VSR channels. The thimbles in the VSR channels prevented the solution from being dispersed in the reactor block. After some years of operation, high corrosion rates on the aluminum thimbles made the reliability of the system questionable. Subsequently, the third safety system was redesigned to eliminate the use of thimbles and liquid boron. The new design used a special seal at the entrance of each HCR and VSR channel to provide a gas seal. The new design also provided a device that permitted small boron balls to flow by gravity into the VSR channels to shut the reactor down in emergency situations. The quantity of waste that resulted from removing the thimbles and boron solution capability is estimated as follows:

- The thimbles were about 35 ft long and 3.5 in. in diameter with a wall thickness of 0.150 in.
- Each thimble weighed about 90 lb.
- When thimbles were eliminated from use, 38 each were removed from B, D, DR and F reactors and 55 from H. There were no thimbles in the C or K Reactors.
- Twenty-three thimbles each were replaced for maintenance purposes in B, D, DR and F and six in H. (H Reactor used thimbles for a very short time which resulted in the lower number replaced at H reactor.)
- Calculation: 61 x 90 lb = 5,490 lb for each reactor

4.7.3 Horizontal Control Rods Assumptions

Horizontal control rods were used to control the nuclear reaction in the reactor. Routine maintenance required replacing the rod tips infrequently. The rod tip sheath is a closed end rectangular tube about 40 ft long by 3.5 in. wide by 1.5 in. The sheath is made from 63-ST-S aluminum. Smaller inlet and outlet aluminum cooling tubes were inside the tip for cooling purposes. Donut-shaped boron rings sized to fit inside the sheath surrounded the cooling tubes for the full length of the rod tip section. The rod tip was then assembled to a drive mechanism to run the rod in and out of the reactor. The tip assembly weighed about 80 lb.

There were nine rods in operation at B, D, DR and F reactors, 15 at C and H reactors, and 20 at the K reactors. The estimated number of HCRs buried during the operating history is based on experience and on extrapolation of the number listed in the 100-B burial log. It is estimated that each HCR was replaced twice during the operating period of each reactor.

4.7.4 Vertical Safety Rod Assumptions

The vertical safety rod system was designed to shut the reactor down and hold the reactor subcritical. The system consisted of 29 VSRs at B, D, DR and F reactors and 45 at C, KE, KW and H reactors. The VSRs were suspended vertically above the reactor with the tip of the VSR inside the biological shield. During an automatic shutdown the VSRs would free-fall into the reactor on demand or could be lowered under power on a manual shutdown. (The K Reactor VSRs were air-driven to accelerate the insertion time.) The size of the VSRs at each reactor was about the same; however, the composition of the VSR was a little different and is explained below. Since the VSRs were not in the active portion of the reactor during operation, only the tip section became radioactive. For the purpose of calculating radionuclide inventory, only about two feet of the VSR should be considered.

The poison section of the VSRs was about 32 ft long and about 3 in. in diameter. The following variation existed in the VSR design.

- B, D and F Reactors. The material used in the VSRs was an alloy of 1.5% boron and 98.5% stainless steel. The material was formed into 3-in. tubing with a wall thickness of 3/16-in. The full-length VSR was constructed in nine sections. Each of the first three sections was 25 in. long and filled with 4-in. thick alternating layers of graphite and steel. The remaining six sections were void in the center.

- DR and H Reactors. The VSRs at DR and H were made of chrome-plated carbon steel tubing and contained a nominal 2.8-in. diameter core made of 5% boron and 95% graphite. The "active" portion of the VSR was assembled in three 10-ft sections.

- C, KE and KW Reactors. The VSRs used in C, KE and KW were made of an alloy of 1.5% boron and 98.5% stainless steel and formed into tubing with a wall thickness of 0.380-in. The full-length rod was assembled in 10-ft sections.

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4.7.5 Nozzles and Pigtails Assumptions

A nozzle with a pigtail (connector) is mounted on the front and rear of each process tube. The nozzle is designed to accommodate a flow measuring device (orifice or venturi) which connects the process tube through a pigtail to a crossheader. The crossheader connects to the main coolant supply. Project CG-558 increased the coolant flow capabilities to the reactors so it was necessary to replace all the inlet nozzles and pigtails and install venturies in the majority of the nozzles to accommodate the higher flows. This project was repeated in all reactors except KE and KW and resulted in about 12,000 excess nozzles and pigtails. In addition, based on experience, 500 nozzles and pigtails were disposed of during routine maintenance at each reactor. The excess nozzles and pigtails were disposed of in the burial grounds of the respective areas. The nozzles were slightly contaminated with low-level radioactive material. A nozzle is estimated to weigh 10 lb and the pigtail 2 lb. Approximately 50% of the nozzles buried were carbon steel and 50% were aluminum; 50% of the pigtails were stainless steel and 50% were aluminum.

Calculation:

500 nozzles and pigtails disposed of during routine maintenance x 8 reactors	= 4,000
Nozzles replaced by Project CG-558	= 12,000
Pigtails replaced by Project CG-558 and other upgrade maintenance	= 60,000
Total nozzles replaced (16,000 x 10 lb ÷ 2,000 lb per ton)	= 80 tons
Total weight of pigtails replaced (60,000 x 2 lb ÷ 2,000 lb per ton)	= 60 tons
Total pigtail and nozzle weight	= 140 tons

4.7.6 Miscellaneous Reactor Tools

A total of 0.5 ton is assigned to each burial ground for burial of contaminated worn-out tools.

4.7.7 Radionuclide Inventory for Miscellaneous Wastes

With the exception of the gunbarrels, very little actual data are available to estimate the radionuclide inventories for miscellaneous waste buried in the 100 Areas. Two samples of carbon steel gunbarrels from the C Reactor were analyzed as part of an earlier characterization study (Reference 2). All other estimates required calculational techniques to arrive at a radionuclide inventory. Items that were contaminated, as opposed to activated, were not assigned a radionuclide inventory value, since, even if an item were grossly contaminated, the curie amount is quite small.

All components fabricated from aluminum, such as HCRs and thimbles were assumed to have 0.001% cobalt and 0.01% nickel as impurities. VSRs at B, D, F, C, KE, and KW were made of stainless steel; the stainless steel was assumed to be austenitic 18-8. Additionally, for the VSRs only the "tip" 6 in. were assumed to be irradiated and only at a thermal neutron flux of 10^8 since the tip resided in the top biological shield during operation.

The estimated radionuclide inventories from the miscellaneous waste items are summarized in Table 7 and in Appendix B.

4.8 CADMIUM SHEETS

Sheets of cadmium were used on special occasions as a graded shield for calibration purposes and to provide neutron shielding where necessary. An inventory of lead and cadmium sheets was made on December 20, 1985, and only 50 lb of cadmium sheets were found in the eight retired reactors. The most common use of sheet cadmium was on the experimental facilities. Discussions with employes who worked with this material indicate that less than 500 lb of cadmium sheets were used. Based on the above information and applying a generous amount of conservatism, an inventory of 100 lb of cadmium sheets is assigned to each of the six primary burial grounds and 200 lb to 118-K-1. This amount has little effect on the total cadmium disposed of when compared to the contribution from the lead-cadmium pieces. The sheets of cadmium were slightly contaminated but do not contribute measurably to the radionuclide inventory in the burial grounds.

4.9 THERMOCOUPLE WIRE

Part of the reactor graphite temperature monitoring system consisted of thermocouple stringers that were installed in nine selected process tube channels in the reactor block. There were 12 wire pairs in each stringer (13 at the K Reactors) that measured the temperature at different locations along the horizontal plane of the channel. The first stringers used were made up of ceramic-insulated wire. These were used in all reactors until the late 1950s when they were replaced with an Inconel-insulated® wire.

The following assumptions are made in calculating the inventory of waste resulting from this system.

- Each reactor except KE and KW replaced nine thermocouple stringers.
- KE and KW replaced four stringers each during the operating history of the two reactors.
- There are 600 ft of thermocouple wire in each stringer.
- The density of nickel (8.90 g/cm^3) was used in calculating the weight of the stringer wire.

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- The thermocouples are made up of paired wire with an outside diameter of 0.0253-in. The positive lead is composed of 20% chromium and 78% nickel. The negative lead is composed of 3% silicon and 97% nickel.

- The calculated weight of wire in each stringer is 6 lb.

Calculation of waste:

(6 reactors x 9 stringers) + (2 reactors x 4 stringers) = 62 stringers
62 stringers x 6 lb = 372 lb

4.10 SOFT WASTE

Soft waste consisting of contaminated plastic, paper, and clothing packaged in cardboard cartons makes up more than 75% of the waste volume in the trenches, but contains a very small percentage of the total radionuclide inventory.

There are no historical records which show the volume generated of this type of waste. Consequently, the estimated volume of soft waste is based on experience and the following assumptions.

4.10.1 Assumptions

- Soft waste was generated during shutdown as well as during operation. Therefore, 142 reactor-years or 51,830 days is used in calculating the estimated soft waste.

- It is estimated that an average of 2.5 cartons of soft waste were generated each reactor-day.

- A carton has a volume of 4.5 ft^3.

- Each loaded carton weighed an average of 25 lb.

4.10.2 Calculation

- 51,830 reactor-days x 2.5 cartons/day = 129,575 cartons

- 129,575 cartons x 25 lb = 3,239,375 lb or 1,600 tons (total rounded to two significant figures)

4.10.3 Radionuclide Inventory of Soft Waste

Previous estimates of radionuclides disposed of in the burial grounds with the soft waste varies from 1% to 10% of the total radionuclides in the burial grounds. There is no documented information to support any percentage chosen. However, it is known from experience that most of the soft waste was composed of step-off pads, paper and plastic used to expedite cleanup of radiation zones established during outages, worn-out clothing used in radiation zones, and contaminated rags used in the cleanup of a

9 2 1 2 5 1 0 7 0

radiation zone and contaminated equipment. The bulk of this material was only slightly contaminated and contained only small amounts of radionuclides. For the purpose of this document it was estimated that 5% of the total radionuclide inventory in the burial grounds is attributable to the soft waste.

5.0 SPECIAL PROGRAMS BURIAL SITES

5.1 TRITIUM SEPARATION PROGRAM

A special tritium separation program was operated at 100-B Area from the late 1940s until 1952. Tritium was produced in the reactor by irradiating an aluminum-clad lithium target. A pilot separation line was set up in the 108-B Building to extract tritium from irradiated material (P-10 Project). Originally, five glass process lines served as a prototype for the metal process line. The separations process began by removing the aluminum cladding from the target material and disposing of it in the burial grounds. The target material was then placed in an 18-in. x 8-in. stainless steel tube container or pot container and melted down with lead to extract the product.

A number of materials were buried as waste from this process. The stainless steel container and the remnants in it were buried as waste. Remnants consisted of metal hydrides of lithium, aluminum, and lead. Mercury used as the pumping material in the diffusion pumps was present throughout the waste. Palladium employed initially as a diffusion separator and later as a sorption bed separator would be found in discrete packages in the burial grounds. Natural and perhaps some depleted uranium, as well as zirconium, were used as driers and as sorption beds. In addition, classical drying agents such as solva beads, activated charcoal, and deliquescent compounds often derived from calcium will be found in the waste. The amount of drying agents disposed is unknown; however, there would be significant volumes because the drying agents were used each time air was admitted into a line to pressurize it. The appurtenances to the lines themselves were also buried, such as the fore pumps which are similar in design to a refrigerator compressor. These systems operated in oil that was contaminated with tritium and will be found in the burial grounds along with the pumps.

When the glass lines were removed, the components, as well as the waste generated during operation of this line, were buried in 118-B-1 (105-B Burial Ground). The metallic waste generated during operation of the metal line was placed in a separate burial ground, 118-B-6 (108-B Solid Waste Burial Ground).

Waste volumes and the assumptions used to calculate them for both the glass and metal process lines follow.

5.1.1 Tritium Separation Glass Lines

Estimated Waste Buried in 118-B-1

. Spent lithium-aluminum alloy	37,500 lb
. Lead from pots	30,000 lb
. Mercury from disposal of glass line	2,000 lb
. Glass from glass line	2,500 lb
. Aluminum cladding	3,000 lb
. Palladium	Trace amount

Assumptions - Glass Lines

- The waste estimates are based on information collected from knowledgeable individuals who developed and operated the glass line prototypes.
- All waste resulting from the operation and disposal of the glass lines was placed in 118-B-1, the 105-B Burial Ground.
- Product yield from separation was eventually 85%.
- The glass line completed perhaps 40% of the total separations campaign in 108-B.
- Each target capsule contained between 50 and 100 cm^3 of tritium at Standard Temperature and Pressure.
- Aluminum cladding was 4 in. long with a 0.35-in. wall thickness and weighed 0.1 lb each. The aluminum was grade 2S.
- There were 7,500 pots processed with an average of four pieces per pot (plus one unirradiated lead piece).
- The majority of mercury was from the manometers and Toepler pumps which were disposed of with the glass lines.

5.1.2 Tritium Separation Metal Line

Estimated Waste Buried in 118-B-6

Spent lithium-aluminum alloy	58,500 lb
Lead from pots	47,000 lb
Mercury from manometers and Toepler pumps	100 lb
Aluminum cladding	3,800 lb
Palladium	3,000 lb

Assumptions - Metal Line

- The waste estimates are based on information collected from knowledgeable individuals who operated the metal line.
- All waste from the metal line was disposed of in 118-B-6, the 108-B Solid Waste Burial Site.
- Product yield from separation was 95%.
- The metal line completed at least 60% of the total separations campaign.
- Each target capsule contained between 50 and 100 cm^3 of tritium at Standard Temperature and Pressure.

- Aluminum cladding was 4 in. long with a 0.35-in. wall thickness and weighed 0.1 lb each. The aluminum was grade 2S.
- There were 11,700 pots processed with an average of four pieces per pot (plus one unirradiated lead piece).
- The metal line was left in place at the end of the separations campaign and was removed in 1985 when the 108-B Building was decontaminated prior to decommissioning the facility. When the system was decommissioned, the remaining mercury was packaged and transported to the 200 Area for disposal as hazardous material.

5.1.3 Radionuclide Inventory

The contribution of radionuclides to the 118-B-1 Burial Ground from the tritium separations is 3800 curies and to the 118-B-5 Burial Ground is 11,000 curies.

5.2 N REACTOR WASTE DISPOSAL IN 118-K-1 AND 118-B-1

5.2.1 118-K-1 Burial Ground

Before closing 118-K-1 (100-K Burial Ground), some waste from the 105-N Fuel Storage Basin was disposed of at the site in a 60-in. corrugated culvert. Buried vertically, the culvert is located inside the 118-K-1 Burial Ground boundary and is not included in other estimates of waste for this location.

The waste was predominantly zirconium cladding (skins) from the lithium target elements irradiated in N Reactor. Also included in the waste were zirconium fuel supports (feet) which came loose from the irradiated fuel elements during discharge from the reactor and a small amount of corrosion-product sediment that had collected on the storage basin floor.

The composition of waste in each burial cask is estimated at 98% zirconium cladding, 1% fuel supports, and 1% sediment.

The total compacted volume buried in the culvert container is as follows:

Zirconium:	235 ft^3	Cladding
	11 ft^3	Fuel Supports
Sediment:	12 ft^3	

<u>Assumptions Made in Estimates</u>

- Burial cask inside measurements were 6 x 5 x 5 ft for a cask volume of 150 ft^3.
- Casks were filled to capacity.
- Eight cask loads were placed in the culvert.
- Fuel supports randomly oriented can be compacted to 90% of volume.

9 2 1 2 3 0 1 0 7 4

- Cladding randomly oriented as dumped into cask can be compacted to 20% of volume.

- Concentrations of the radioactive material in the sediment are based on the results from the samples taken from the N basin.

Calculations

Total volume: 150 ft^3 x 8 = 1200 ft^3
Solid mass zirconium cladding: 0.98 x 1200 = 1176 x 0.20 = 235 ft^3
Solid mass fuel supports: 0.01 x 1200 = 12 x 0.90 = 11 ft^3
Sediment (i.e., activated corrosion product): 0.01 x 1200 = 12 ft^3

Radionuclide Inventory of N Reactor Waste in 118-K-1

The radionuclide inventory of the Zircalloy-2 scrap generated at the N Reactor and disposed of in the 118-K-1 culvert was calculated. The inventory was based on common impurities found in Zircalloy-2 materials; i.e., niobium (14 ppm) and molybdenum (50 ppm). Of course, zirconium itself produces a long-lived radionuclide, Zr-93. Neutron activation of molybdenum produces two radionuclides that may be of interest in the long-term, Tc-99 and Mo-93. Neutron activation of niobium produces Nb-94. The curies amounts of each of the four radionuclides were calculated using the N Reactor central zone thermal neutron flux and assuming a two-month irradiation time. The values are shown in Table 9 and in Footnote 4 of Table 10.

5.2.2 118-B-1 Burial Ground

Project waste from replacing the primary cooling tubes in eight steam generators at N Plant was disposed of in the 118-B-1 Burial Ground. The total weight of tubing from this project is calculated to be 250 tons of stainless steel tubes. In each of the eight steam generators there were 1,916 tubes (5/8-in. outside diameter, 0.049-in. wall thickness) made of 304 stainless steel, representing a total of 200,000 linear ft.

5.3 BIOLOGY LABORATORY DISPOSAL

The PNL Sawdust Repository, 118-F-5, consists of sawdust and other solids removed from the dog kennels and swine pens and is located outside the old perimeter road east of the 188-F Ash Disposal Area. The disposal at this site was begun in about 1958. Since that time, about 10,000 yd^3 of sawdust containing strontium-90 and some plutonium-239 have been deposited. The solids at this site have been covered with a 4-ft layer of soil. The volume of waste is estimated to be 3,000 ft^3.

The PNL Solid Waste Burial Ground, 118-F-6, is located about one-half mile southwest of the 108-F Building and adjoins the south end of a much larger, retired burial ground (118-F-1). The site also contains a buried steel tank with a vent (commonly referred to as the "submarine") which was formerly used to incinerate slightly contaminated animal carcasses. Placed in service in 1955, the burial site received solid wastes consisting almost exclusively of strontium-90 until it was retired in 1975. The estimated volume of waste is 10,000 ft^3.

Additional detail on the waste disposed of under the Biological Laboratory Program at 100-F can be found in a letter from W. D. Richmond to Mr. M. R. Schneller, DOE-RL, dated March 31, 1971, and in a letter covering radionuclide inventories in 118-F-5 from V. R. Richards to J. J. Dorian dated August 10, 1981, included as Appendix D.

5.3.1 Radionuclide Inventory

See Appendix D for details.

6.0 OTHER SMALL BURIAL SITES

6.1 118-C-2 (105-C BALL STORAGE TANK)

A prototype hot ball sorter was used at 105-C to test the feasibility of sorting 3X balls that had become activated from balls that were not activated (see Section 4.7.2 for a discussion of the emergency shutdown system). The activated balls that were sorted out were disposed of in the 118-C-2 burial site. There are no records of the number of balls or activation level of these balls. The quantities estimated in this report are based on the experience of individuals who were involved in reactor operation.

It is estimated that the 118-C-2 Burial Ground contains about one reactor inventory of balls, which is equivalent to about 10 tons of 3X balls. The balls, 3/8-in. in diameter, are a mixture of 70% nickel-plated boron steel and 30% carbon steel.

6.2 118-F-4 (115-F DESICCANT PIT)

The 115-F pit (118-F-4) was a small 10 x 10-ft pit used to dispose of the silica gel or desiccant from one drier in the 115-F gas recirculation facility. The desiccant from one gas drier measures 200 ft^3 and weighs 600 lb.

6.3 118-H-2

Special irradiation test facilities were designed as part of the 105-H Reactor operation. The facility was used for various tests and special irradiations programs. As part of one test, a stainless steel tube 40 ft long, 3 in. in diameter and with a wall thickness of 0.125 in. was removed for metallurgical study and was buried in the 118-H-2 Burial Ground.

7.0 SUMMARY OF INVENTORIES

The results of the inventory calculations are presented in the following tables. Table 7 shows the total combined waste generated only as a direct result of reactor operation. Table 8 shows the estimated waste resulting from the 108-B tritium separation program. Table 9 shows the waste from the N Reactor fuel storage basin cleaning. Tables 10, 11 and 12 summarize the estimated radionuclides and metallic and other wastes by individual burial ground.

The numbers in these tables are rounded to two significant figures and the inventories are estimated to be accurate to plus 50, minus 20%. Radionuclide inventories are decayed to June 1, 1987.

9 2 1 2 5 0 1 0 7 8

TABLE 7. Reactor Operation Waste[1]

Type of Waste	Quantity (Tons)	Radionuclides (Curies as of June 1, 1987)										
		^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{108m}Ag	^{133}Ba
Aluminum Spacers	425	NA	NA	0.2	T	T	T	T	T	T	-0-	-0-
Lead-Cadmium Pb Cd	1059 44	NA	NA	8.0	T	T	T	T	T	T	46.0	2.5
Poison Splines Al B	62.5 8.5	NA	NA	7.4	T	T	-0-	-0-	-0-	-0-	-0-	-0-
Graphite from Broaching	0.70	5.0	2.0	T	T	T	T	T	T	T	-0-	-0-
Graphite from Overbore	0.50	2.1	1.1	T	T	T	T	T	T	T	-0-	-0-
Aluminum tubes	266	NA	NA	1420	1460	12.4	1.8	1.8	15.0	9.0	-0-	-0-
Desiccant (silica gel)	6.6	9.0	0.35	NA	NA	-0-	NA	NA	NA	NA	-0-	-0-
Lead Shielding	258	1.0	0.10	1.0	0.10	-0-	0.10	0.10	1.0	1.8	-0-	-0-
Miscellaneous[2]	145.8	-0-	0.1	293	344	2.8	-0-	-0-	-0-	-0-	-0-	-0-
Cadmium Sheets	0.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soft Waste	1620	0.85	T	90.5	90.4	-0-	T	T	0.8	0.55	2.3	T
Thermocouples	0.18	-0-	-0-	T	T	T	-0-	-0-	-0-	-0-	T	-0-
Ball 3X System Balls	10	NA	NA	80	1.6	T	NA	NA	NA	NA	NA	NA
TOTALS	3966.98	18.0	4.0	1900	1898	15	2.0	2.0	17	12	48	3.0

NA - Not applicable
T - Trace amounts of less than 0.1 curie.
(1) Included in primary burial grounds 118-B-1, 118-C-1, 118-D-2, 118-D-3, 118-F-1, 118-H-1, and 118-K-1.
(2) Includes gunbarrels, HCR/VSR thimbles, horizontal control rods, vertical safety rods, nozzles, pigtails, and a variety of contaminated reactor maintenance tools.

TABLE 8. Tritium Separation Program Waste

	Type of Waste	Quantity (Tons)	^{3}H Inventory[1] (Curies)
Glass Lines[2]			
	Spent Li-Al Alloy	18.8	
	Lead	15.0	
	Mercury	1.0	
	Glass	1.25	
	Al Cladding	1.5	
	Palladium	Trace	
	Radionuclide		3800
Metal Line[3]			
	Spent Li-Al Alloy	23	
	Lead	18	
	Mercury	0.05	
	Al Cladding	1.9	
	Palladium	1.5	
	Radionuclide		11,000

(1) All waste was contaminated with tritium (^{3}H). A total inventory is listed because the exact degree of contamination for each material is not known.
(2) All waste from the glass line was disposed in 118-B-1.
(3) All waste from the metal line was disposed in 118-B-6.

TABLE 9. N Reactor Basin Waste

Type of Waste	Quantity	Radionuclides (Curies) ^{93}Z	^{43}MO	^{94}Nb	^{99}Tc
Storage Basin(1)					
Zirconium(2)		2.1	0.03	0.07	0.0007
Cladding	235 ft^3				
Fuel Supports	11 ft^3				
Sediment	12 ft^3				
Steam Generator					
Tube Replacement					
Stainless Steel(3)	270 tons	Total radionuclide inventory is estimated to be <0.01.			

(1) Waste was disposed in 118-K-1.
(2) Radionuclide inventories are totals for the zirconium. Sediment is not calculated.
(3) Waste disposed of in 118-B-1.

TABLE 10. Radionuclide Summary

Burial Site	Radionuclides (Curies)											
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{133}Ba	^{41}Ca	^{108m}Ag
118-B-1	3,800	0.24	323	258	0.3	0.3	0.3	2.3	1.6	0.5	0.01	9.0
118-B-2	-	-	1	-	-	-	-	-	-	-	-	-
118-B-3	-	-	1	-	-	-	-	-	-	-	-	-
118-B-4	-	-	1	-	-	-	-	-	-	-	-	-
118-B-5	-	-	1	-	-	-	-	-	-	-	-	-
118-B-6	11,000	-	-	-	-	-	-	-	-	-	-	-
118-B-7	-	-	1	-	-	-	-	-	-	-	-	-
118-C-1	3.5	1.3	203	174	1.3	0.2	0.3	1.3	0.08	0.2	0.01	4.7
118-C-2	-	-	80	1.6	-	-	-	-	-	-	-	-
118-D-1	-	-	1	-	-	-	-	-	-	-	-	-
118-D-2	1.5	0.3	392	262	2.0	0.4	0.4	2.3	1.4	0.5	0.01	9.9
118-D-3	-	-	1	-	-	-	-	-	-	-	-	-
118-D-4	-	-	1	-	-	-	-	-	-	-	-	-
118-D-5	-	-	1	-	-	-	-	-	-	-	-	-
118-DR-1	1.4	0.2	251	195	1.5	0.4	0.4	1.4	1.0	0.3	0.01	6.1
118-F-1	1.5	0.2	332	284	2.2	0.5	0.5	2.2	1.4	0.5	0.01	9.9
118-F-2	-	-	1	-	-	-	-	-	-	-	-	-
118-F-3	-	-	1	-	-	-	-	-	-	-	-	-
118-F-4	0.80	0.02	-	-	-	-	-	-	-	-	-	-
118-F-5(1)												
118-F-6(2)												
118-F-7	-	-	1	-	-	-	-	-	-	-	-	-
118-H-1	1.4	0.2	299	272	2.1	0.4	0.4	1.9	1.2	0.4	0.01	6.6
118-H-2(3)												
118-H-3	-	-	1	-	-	-	-	-	-	-	-	-
118-H-4	-	-	1	-	-	-	-	-	-	-	-	-
118-H-5	-	-	1	-	-	-	-	-	-	-	-	-
118-K-1(4)	5.2	0.9	834	518	4.1	1.4	1.4	4.8	3.3	0.5	-	0.9

(1) Appendix D; also present are 0.30 curies of $^{239/240}Pu$.
(2) Appendix D.
(3) Includes stainless steel tube from 105-H Reactor test loop; see Section 6.3.
(4) Also present are 2.1 curies of ^{93}Zr and trace amounts of ^{93}Mo, ^{94}Nb, and ^{99}Tc.

TABLE 11. Metallic and Other Waste Summary

Burial Site	Metallic and Other Waste (Tons)						
	Lead	Aluminum(1)	Pb/Cd	Boron(2)	Mercury	Graphite	Other(3)
118-B-1	30.0	135.2	201.2/8.4	1.4	1.0	0.08	527
118-B-2(4)	-	-	-	-	-	-	-
118-B-3(4)	-	-	-	-	-	-	-
118-B-4(4)	-	-	-	-	-	-	-
118-B-5(4)	-	-	-	-	-	-	-
118-B-6	18.0	25.0	-	-	0.05	-	23
118-B-7(4)	-	-	-	-	-	-	-
118-C-1	23.8	94.8	105.9/4.4	1.2	-	0.56	211
118-C-2(5)	-	-	-	-	-	-	-
118-D-1(6)	-	-	-	-	-	-	-
118-D-2	109.8	134.4	222.4/9.4	1.4	-	0.08	280
118-D-3	23.8	97.0	137.7/5.7	1.0	-	0.06	181
118-D-4(6)	-	-	-	-	-	-	-
118-D-5(6)	-	-	-	-	-	-	-
118-DR-1(6)	-	-	-	-	-	-	-
118-F-1	23.8	127.8	222.4/9.4	1.3	-	0.07	247
118-F-2(7)	-	-	-	-	-	-	-
118-F-3(7)	-	-	-	-	-	-	-
118-F-4(7)	-	-	-	-	-	-	0.30
118-F-5(8)	-	-	-	-	-	-	-
118-F-6(9)	-	-	-	-	-	-	-
118-F-7(7)	-	-	148.3/6.2	-	-	-	-
118-H-1	23.8	109.9	154.4/6.4	1.0	-	0.05	200
118-H-2	-	-	-	-	-	-	0.30
118-H-3(10)	-	-	-	-	-	-	-
118-H-4	-	-	-	-	-	-	-
118-H-5(10)	-	-	-	-	-	-	-
118-K-1	30.0	208.1	21.1/0.9	3.2	-	0.20	368
TOTALS	283.00	932.2	1059.0/44.0(11)	10.5(2)	1.05	1.1	2047

(1) Includes aluminum cans on Pb/Cd pieces, spacers and aluminum contained in splines.

(2) Includes boron from splines, VSRs and HCRs at 1.5% x total weight buried.

(3) Includes soft waste, desiccant, and miscellaneous materials (see Table 8).

(4) Included in 118-B-1 totals.

(5) Hot balls from ball sorting in 105-C.

(6) Divided between 118-D-2 and 118-D-3 totals.

(7) Included in 118-F-1 totals.

(8) Contained $3x10^5$ ft^3 of contaminated sawdust and other solids removed from dog kennels and animal pens.

(9) Contained $1x10^5$ ft^3 of contaminated solid waste such as animal carcasses.

(10) Included in 118-H-1 totals.

(11) Includes sheet cadmium.

TABLE 12. Breakdown of Other Waste

Burial Ground	Breakdown of Other Waste (Tons)								
	Soft Waste	3X Balls	Dessicant	Misc.	P-10 Program	Thermo-couple Wire	Zirk 100-N Basin	SS Tube Steam Gen.	Total
118-B-1	248.00	-	1.50	19.25	7.80	0.03	-	250.00	527
118-B-6	-	-	-	-	23.40	-	-	-	23
118-C-1	193.00	-	-	17.50	-	0.03	-	-	211
118-C-2	-	10.00	-	-	-	-	-	-	10
118-D-1	259.20	-	1.50	19.25	-	0.03	-	-	279
118-D-3	162.00	-	-	19.25	-	0.03	-	-	181
118-F-1	226.80	-	0.90	19.25	-	0.03	-	-	247
118-F-4	-	-	0.30	-	-	-	-	-	0.30
118-H-1	179.80	-	0.90	19.25	-	0.03	-	-	200
118-H-2	-	-	-	0.30	-	-	-	-	0.30
118-K-1	351.20	-	1.80	8.50	-	0.03	6.00	-	368

(1)This records the contribution of the stainless steel tube from the 105-H test loop.

8.0 REFERENCES

1. "Comprehensive Environmental Response, Compensation, and Liability Act Program," DOE Order 5480.14, U.S. Department of Energy, April 26, 1985.

2. J. J. Dorian and V. R. Richards, Radiological Characterization of the Retired 100 Areas, UNI-946, UNC Nuclear Industries, Richland, WA, 1978.

3. R. L. Miller and J. M. Steffes, editors, Radionuclide Inventory and Source Terms for the Surplus Production Reactors at Hanford, UNI-3714 Rev. 1, UNC Nuclear Industries, Richland, WA, April 1987.

APPENDIX A

ANNOTATED LIST OF RADIOACTIVE SOLID WASTE BURIAL GROUNDS IN THE HANFORD 100 AREAS

APPENDIX A

ANNOTATED LIST OF RADIOACTIVE SOLID WASTE BURIAL GROUNDS IN THE HANFORD 100 AREAS

Table A.1 shows the identity and general use of the solid waste burial grounds in the 100 Area:

TABLE A.1. Burial Ground Uses

Facility Number	Facility Name	Description
118-B-1	105-B Burial Ground	Primary burial ground for 105-B Reactor. Received the bulk of solid waste from the operation of 105-B Reactor. In addition, the waste from the tritium separation program glass line (108-B Building) was placed here.
118-B-2	Construction Burial Ground No. 1	Construction burial ground that received solid waste from the 107-B basin repairs and waste from 115-B gas building conversion to serve both B and C Reactors (original 115 served 105-B only). Material was slightly contaminated but did not contribute significantly to the radionuclide inventory.
118-B-3	Construction Burial Ground No. 2	Construction burial ground used for disposal of contaminated waste from modifications to the effluent lines. The bulk of the waste was 54-in. cold-rolled steel pipe with low-level contamination. Not considered to contribute significantly to the radionuclide inventory.
118-B-4	105-B Spacer Burial Ground	Starting about 1956, the used spacers were stored for recovery and reuse at a later time. Contents of this burial site are included in the inventory for 118-B-1.
118-B-5	Ball 3X Burial Ground	Burial ground for waste from the conversion of a liquid 3X system to a ball 3X system. The contaminated waste at this burial site was included in the inventory for 118-B-1.
118-B-6	108-B Solid Waste Burial Ground	Used for the bulk of metallic solid waste generated during the metal line operation of the tritium separation program.

TABLE A.1 (Contd)

Facility Number	Facility Name	Description
118-B-7	111-B Solid Burial Ground	Received small amount of waste from the 111-B facility which was used originally as a reactor fuel inspection and charge makeup station. Following about one year as a reactor fuel inspection station, it was used as an equipment decontamination facility and shop for working on low-level contaminated equipment. There was very little waste generated in this building that was not disposed of in the 118-B-1 Burial Ground.
118-C-1	105-C Burial Ground	Primary burial ground for 105-C Reactor operation waste.
118-C-2	105-C Ball Storage Tank	A "hot" ball sorter prototype was developed at 105-C and the ball tanks were used to dispose of the 3X balls that were radioactive.
118-D-1	100-D Burial Ground No. 1	Received solid waste generated at 105-D. Since an accurate accounting cannot be made, the contents of this burial site are included in 118-D-2.
118-D-2	100-D Burial Ground No. 2	Primary burial ground for 105-D Reactor operation waste.
118-D-3	100-D Burial Ground No. 3	Primary burial ground for 105-DR Reactor operation waste.
118-D-4	Construction Burial Ground	Used to bury waste generated from special project-type maintenance. The construction waste contained low-level contamination and is not considered significant to the total radionuclide inventory.
118-D-5	Ball 3X Burial Ground	Received waste generated during the conversion from liquid to ball 3X system. The waste deposited in this burial site is included in 118-D-2 and 118-D-3.
118-DR-1	105-DR Gas Loop Burial Ground	Used to process special components used in the loop. Does not contain significant amounts of contaminated waste. All high-level radioactive material was removed prior to closing the burial grounds.
118-F-1	Burial Ground No.1	Primary burial ground for 105-F Reactor operation waste.
118-F-2	Burial Ground No. 2	Received waste generated during project modifications and major maintenance to effluent system, rupture monitor detection equipment, and downcomer repair. Does not contain significant quantities of radionuclides.

TABLE A.1 (Contd)

Facility Number	Facility Name	Description
118-F-3	Burial Ground No. 3	Received waste generated during the conversion from a liquid 3X safety system to a ball 3X safety system. The waste deposited in this burial site is included in the calculations for 118-F-1.
118-F-4	115-F Pit	A small pit (10 x 10 ft) was excavated to dispose of the silica gel from one drier. The drier media was used to collect moisture from the gas recirculated through the reactor.
118-F-5	PNL Sawdust Repository	Received low-level activity sawdust from animal pens used for biological studies by Battelle PNL.
118-F-6	PNL Solid Waste Burial Ground	Received animal and laboratory waste resulting from biological tests at 100-F.
118-F-7	Miscellaneous Hardware Storage Vault	Used reactor parts that were slightly contaminated were stored in this vault for possible recovery and reuse. When there was no longer need for the parts, the vault was closed out and added to the list of burial sites. Contains only small amount of low-level radioactive materials.
118-H-1	100-H Burial Ground No. 1	Primary burial ground for 105-H Reactor operation waste.
118-H-2	100-H Burial Ground No. 2	Received stainless steel tube removed from the reactor in 1955. During deactivation of H Plant, area was used for disposal of a small amount of contaminated pipe.
118-H-3	Construction Burial Ground	Received sections of contaminated pipe used as chutes for removal of thimbles from 105-H. The chutes were also used during other maintenance and upgrade work.
118-H-4	Ball 3X Burial Ground	Received thimbles and other waste generated during conversion from liquid to ball 3X safety system. Inventory of radionuclides from the thimbles is included in 118-H-1.
118-H-5	105-H Thimble Pit	Received thimble assembly from the experimental hole B. When the confinement project was done at 105-H, the excavation work required removal of the pluto crib which was dug up and moved to this burial site.
118-K-1	100-K Burial Ground (118-K)	Primary burial ground for 105-KE and -KW Reactor operation waste. The only solid waste burial ground in 100-K.

A P P E N D I X B

INVENTORY OF RADIOACTIVE MATERIALS IN THE PRIMARY SOLID WASTE BURIAL GROUNDS IN THE HANFORD 100 AREAS

APPENDIX B

INVENTORY OF RADIOACTIVE MATERIALS IN THE PRIMARY SOLID WASTE BURIAL GROUNDS IN THE HANFORD 100 AREAS

TABLE B.1. 118-B-1 Burial Site

Type of Material	Radionuclides (Curies as of June 1, 1987)											
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{133}Ba	^{41}Ca	^{108m}Ag
Al Tubes & Tube Film	-	-	229	213	1.7	0.2	0.2	2.2	1.4	-	-	-
Al Spacers	-	-	0.01	-	-	-	-	-	-	- -	-	
Irrad. Pb-Cd (Al + film)	-	-	1.5	-	-	-	-	-	-	0.5	-	9.0
Splines	-	-	1.1	-	-	-	-	-	-	-	-	-
Broach Dust	0.4	0.2	-	0.01	-	-	-	0.002	0.001	0.001	0.009	-
Desiccant	1.1	0.04	-	-	-	-	-	-	-	-	-	-
Lead	0.1	0.1	0.1	-	-	-	-	0.1	0.2	-	-	-
Misc.(1) Waste	-	-	28.0	36.0	0.3	-	-	-	-	-	-	
Soft(2) Waste	-	-	13	12.5	-	0.01	0.01	-	-	-	-	-

(1) Includes gunbarrels, nozzles, pigtails, horizontal control rods, vertical safety rods, aluminum thimbles and miscellaneous reactor maintenance tools.
(2) Includes paper, masking tape, plastic, wiping rags, etc.

TABLE B.2. 118-C-1 Burial Site

Type of Material	Radionuclides (Curies as of June 1, 1987) ^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{133}Ba	^{41}Ca	^{108m}Ag
Al Tubes & Tube Film	-	-	143	105	0.8	0.1	0.1	1.2	0.7	-	-	-
Al Spacers	-	-	0.01	-	-	-	-	-	-	-	-	-
Irrad. Pb-Cd (Al + film)	-	-	0.8	-	-	-	-	-	-	0.2	-	4.7
Splines	-	-	1.0	-	-	-	-	-	-	-	-	-
Broach Dust	2.4	1.3	0.01	0.02	-	-	0.01	0.012	0.006	0.001	0.01	-
Desiccant	1.1	0.04	-	-	-	-	-	-	-	-	-	-
Lead	-	-	0.1	-	-	-	-	0.1	0.2	-	-	-
Misc.(1) Waste	-	-	38	60	0.5	-	-	-	-	-	-	-
Soft(2) Waste	-	-	9.6	8.2	-	0.1	0.01	-	-	-	-	-

(1) Includes gunbarrels, nozzles, pigtails, horizontal control rods, vertical safety rods, aluminum thimbles and miscellaneous reactor maintenance tools.
(2) Includes paper, masking tape, plastic, wiping rags, etc.

TABLE B.3. 118-D-2 (105-D) Burial Site

Type of Material	Radionuclides (Curies as of June 1, 1987)											
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{133}Ba	^{41}Ca	^{108m}Ag
Al Tubes & Tube Film	-	-	263	217	1.7	0.3	0.3	2.2	1.4	-	-	-
Al Spacers	-	-	0.01	-	-	-	-	-	-	-	-	-
Irrad. Pb-Cd (Al + film)	-	-	1.7	-	-	-	-	-	-	0.5	-	8.9
Splines	-	-	1.1	-	-	-	-	-	-	-	-	-
Broach Dust	0.4	0.22	0.005	0.13	-	-	0.001	0.002	0.001	0.001	0.01	-
Desiccant	1.1	0.04	-	-	-	-	-	-	-	-	-	-
Lead	-	-	0.1	-	-	-	-	0.1	-	-	-	-
Misc.(1) Waste	-	-	28	36	0.3	-	-	-	-	-	-	-
Soft(2) Waste	-	-	14.6	12.6	-	0.01	0.01	-	-	-	-	-

(1) Includes gunbarrels, nozzles, pigtails, horizontal control rods, vertical safety rods, aluminum thimbles and miscellaneous reactor maintenance tools.
(2) Includes paper, masking tape, plastic, wiping rags, etc.

TABLE B.4. 118-D-3 (105-DR) Burial Site

Type of Material	Radionuclides (Curies as of June 1, 1987)											
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{133}Ba	^{41}Ca	^{108m}Ag
Al Tubes & Tube Film	-	-	122	150	1.2	0.2	0.3	1.3	0.8	-	-	-
Al Spacers	-	-	0.01	-	-	-	-	-	-	-	-	-
Irrad. Pb-Cd (Al + film)	-	-	1.0	-	-	-	-	-	-	0.33	-	6.1
Splines	-	-	0.8	-	-	-	-	-	-	-	-	-
Broach Dust	0.3	0.17	0.004	0.01	-	-	0.001	0.002	0.001	0.001	0.007	-
Desiccant	1.1	0.04	-	-	-	-	-	-	-	-	-	-
Lead	-	-	0.1	0.1	-	0.1	0.1	0.1	0.2	-	-	-
Misc.(1) Waste	-	-	28	36	0.3	-	-	-	-	-	-	-
Soft(2) Waste	-	-	7.6	9.3	-	0.01	0.01	-	-	-	-	-

(1) Includes gunbarrels, nozzles, pigtails, horizontal control rods, vertical safety rods, aluminum thimbles and miscellaneous reactor maintenance tools.
(2) Includes paper, masking tape, plastic, wiping rags, etc.

TABLE B.5. 118-F-1 Burial Site

Type of Material	Radionuclides (Curies as of June 1, 1987)											
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{133}Ba	^{41}Ca	^{108m}Ag
Al Tubes & Tube Film	-	-	201	239	1.9	0.3	0.3	2.1	1.2	-	-	-
Al Spacers	-	-	0.01	-	-	-	-	-	-	-	-	-
Irrad. Pb-Cd (Al + film)	-	-	1.6	-	-	-	-	-	-	0.52	-	9.9
Splines	-	-	1.0	-	-	-	-	-	-	-	-	-
Broach Dust	0.36	0.20	0.005	0.012	-	-	0.001	0.002	0.001	0.001	0.008	-
Desiccant	1.1	0.04	-	-	-	-	-	-	-	-	-	-
Lead	-	-	0.1	0.1	-	0.1	0.1	0.1	0.2	-	-	-
Misc.(1) Waste	-	-	28	36	0.8	-	-	-	-	-	-	-
Soft(2) Waste	-	-	11.6	13.7	-	0.01	0.01	-	-	-	-	-

(1) Includes gunbarrels, nozzles, pigtails, horizontal control rods, vertical safety rods, aluminum thimbles and miscellaneous reactor maintenance tools.
(2) Includes paper, masking tape, plastic, wiping rags, etc.

TABLE B.6. 118-H-1 Burial Site

Type of Material	Radionuclides (Curies as of June 1, 1987)											
	^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{133}Ba	^{41}Ca	^{108m}Ag
Al Tubes & Tube Film	-	-	155	203	1.6	0.02	0.02	1.8	1.0	-	-	-
Al Spacers	-	-	0.01	-	-	-	-	-	-	-	-	-
Irrad. Pb-Cd (Al + film)	-	-	1.1	-	-	-	-	-	-	0.35	-	6.6
Splines	-	-	0.8	-	-	-	-	-	-	-	-	-
Broach Dust	0.27	0.15	0.004	0.01	-	-	0.001	0.002	0.001	0.001	0.007	-
Desiccant	1.1	0.04	-	-	-	-	-	-	-	-	-	-
Lead	-	-	0.1	0.1	-	0.1	0.1	0.1	0.2	-	-	-
Misc.(1) Waste	-	-	42	60	0.5	-	-	-	-	-	-	-
Soft(2) Waste	-	-	9.9	13.1	-	0.01	0.01	-	-	-	-	-

(1) Includes gunbarrels, nozzles, pigtails, horizontal control rods, vertical safety rods, aluminum thimbles and miscellaneous reactor maintenance tools.
(2) Includes paper, masking tape, plastic, wiping rags, etc.

TABLE B.7. 118-K-1 Burial Site

Type of Material	Radionuclides (Curies as of June 1, 1987) ^{3}H	^{14}C	^{60}Co	^{63}Ni	^{59}Ni	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{133}Ba	^{41}Ca	^{108m}Ag
Al Tubes & Tube Film	-	-	532	434	3.5	0.5	0.5	4.6	2.9	-	-	-
Al Spacers	-	-	0.03	-	-	-	-	-	-	-	-	-
Irrad. Pb-Cd (Al + film)	-	-	0.15	-	-	-	-	-	-	0.05	-	0.9
Splines	-	-	1.6	-	-	-	-	-	-	-	-	-
Broach Dust	3.0	0.84	.013	0.33	-	0.001	0.004	0.005	0.002	0.004	-	-
Desiccant	2.2	0.08	-	-	-	-	-	-	-	-	-	-
Lead	0.2	-	0.3	-	-	-	-	0.2	0.4	-	-	-
Misc.(1) Waste	-	-	100	80	-	0.6	-	-	-	-	-	-
Soft(2) Waste	-	-	31.7	25.7	-	0.03	0.03	-	-	-	-	-

(1) Includes gunbarrels, nozzles, pigtails, horizontal control rods, vertical safety rods, aluminum thimbles and miscellaneous reactor maintenance tools.
(2) Includes paper, masking tape, plastic, wiping rags, etc.

APPENDIX C

PERSONNEL SOURCES

APPENDIX C

PERSONNEL SOURCES

Personnel interviewed to provide information for this report are listed in Table C.1 with their experience area, company, and service dates.

TABLE C.1. Personnel Interviewed

Name	Company	Area of Expertise	Hanford Service Date
F. H. Bouse	Retired	Historical Records	1/28/47
R. M. Buslach	Retired	Reactor Maintenance	3/1/47
H. W. DeHaven	Retired	Radiological Protection	3/10/48
A. E. Demers	Retired	Materials Irradiation and Testing	7/17/47
L. E. Denton	Retired	Operations Supervisor and Manager of Maintenance and Surveillance - Deactivated Facilities	10/23/43
E. A. Eschbach	PNL	Tritium Separation - Research & Development	8/30/48
J. Fatur	Retired	Reactor Maintenance	9/1/46
K. E. Fields	WHC	Manager of N Plant Maintenance Planning	9/11/49
R. A. Frister	WHC	Reactor Operations	10/2/47
J. L. Goodnow	Retired	Operations and Reactor Deactivation	9/1/46
R. A. Hayward	Retired	Supervisor of Power Operations	9/1/46
R. N. Henderson	WHC	Reactor Operator	1/28/48
D. S. Lewis	Retired	N Plant Operations	7/16/44
V. R. Richards	WHC	Radiological and Environmental Protection	10/30/50
E. A. Weakley	WHC	Engineering Tritium Separation	6/19/50
R. A. Winship	WHC	Radiological Protection and Reactor Deactivation	8/30/51

APPENDIX D

LETTERS DISCUSSING MATERIAL BURIED IN 118-F-5 AND 118-F-6 IN 100-F AREA

*Facsimile

March 31, 1971

bcc: JP Corley
HV Larson
CM Unruh
EE Voiland
FW Woodfield
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LB -WDR

External Distribution

JJ Cadwell - WADCO
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Mr. M. R. Schneller, Director
Technical Services Division
Richland Operations Office
U.S. Atomic Energy Commission
Richland, Washington 99352

Dear Mr. Schneller:

Waste Management Records on
In-Soil-Stored Radioactivity

Reference: Letter, M. R. Schneller to E. Albaugh, same subject, dated December 31, 1970.

We have reviewed our records for PNL facilities which might contain radioactivity in soil as a result of either planned storage or accidental spills. The period of reference includes not only that under Battelle-Northwest management but also of previous periods of usage. A summary of pertinent information is presented in the attached tables and descriptive material.

Table I shows known disposal sites associated with PNL facilities, with our most recent estimates of quantities. Those assigned facilities for which we have no record of associated in-soil storage, planned or otherwise, are listed in Table II. Listed in Table III are several facilities in the 200 Areas in which Battelle Northwest is a tenant but for which ARHCO has reporting responsibility for routine releases of liquid and solid wastes. It is our understanding that ARHCO is including in a report similar to that requested in the referenced letter those accidental releases which have resulted in soil contamination within the immediate perimeter of such facilities.

We trust this information fills your needs. If any questions arise J. P. Corley of our Occupational Environmental Safety Department can provide additional details and explanation.

Very truly yours,
Signed
W. D. Richmond, Manager
Assistant Laboratory Director

WDR/CLB

Attachments
In Triplicates

*Facsimile-File copy of original is a poor reproduction and is difficult to read.

Table I

Pacific Northwest Laboratory Disposal Sites (Planned and Unplanned)
(as of 3-31-71)

Site	Location (Plant Coordinates)*	Form Of Radioactivity	Period Of Use	Volume	Radio-nuclide	Quantity (Ci)	Storage Rationale
100-F Area							
leach trench (east of 141-N)	N80140/W28880, N80110/W28910, N79840/W28640, N79860/W28610	liquid	1966-present (active)	$9x10^7$ gal.	^{90}Sr ^{239}Pu	4. 0.08	Planned
sawdust repository (east of old perimeter road)	N78870/W28070, N78680/W27650, N78520/W27720, N78680/W28160	solid	1958-present (active)	$3x10^5$ ft^3	^{90}Sr ^{239}Pu	15. 0.3	Planned
141-C Building perimeter	N79950/W29370, N79930/W29370, N79950/W29490, N79930/W29430, N79800/W29490, N79800/W29460	liquid	1958-present	unknown	^{90}Sr	~0.001	Unplanned
east of 141-C (1000 ft^2)	N79870/W29340	liquid	3-13-71	<$1x10^3$ gal.	^{90}Sr	0.005	Unplanned
burial ground 118-F-6 ?	N77660/W31750, N77660/W31610, N77400/W31750, N77400/W31610	solid	1955-present (active)	$1x10^5$ ft^3	^{90}Sr	~15.	Planned
plots used for growing crops (southeast of 141-L)	N76810/W33320	liquid	~1955-present (active - surveillance only)	small	^{90}Sr ^{137}Cs	0.03 0.1	Planned

Table I - General Descriptive Material

The 100-F Leach Trench receives liquid effluents containing small quantities of ^{90}Sr and much smaller quantities of ^{239}Pu which flow from dog kennels and swine pens via 141-N (sawdust separator). The trench is about 400 feet long and about 40 feet wide and typically receives a liquid flow of about 50,000 gpd. It was put into service in June 1966. The radionuclide inventories presented in Table I for this site include dredgings from the trench bottom which have been piled adjacent to the trench.

The sawdust repository consists of sawdust and other solids removed from the dog kennels and swine pens (via 141-N) and is located outside the old perimeter road east of the 188 Ash Disposal Basin. The disposal of sawdust at this site was begun in about 1958, and since that time, about 10,000 cubic yards of sawdust containing ^{90}Sr and some ^{239}Pu have been deposited. The solids at this site have been covered with a thin layer of soil.

The soil at the immediate perimeter of the 141-C Building (Hog Barn) has received seepage (run-off) from floor flushing in the building. Almost all of the flush liquids are caught in troughs and proceed to the leach trench via 141-N, however, small volumes of liquids potentially containing ^{90}Sr have seeped into the soil at the building perimeter.

An area east of 141-C measuring about 1000 square feet was contaminated with ^{90}Sr on March 13, 1971 when liquids were pumped from a manhole in order to unblock a plugged sewer line. It is estimated that less than 5 mCi of ^{90}Sr were released to the ground. The area has been covered with dirt and will be stabilized further or removed for burial.

The 100-F Biology Burial Ground is located about one half mile southwest of the 108-F Building and adjoins the south end of a much larger, retired DUN burial ground. The site also contains a buried steel tank with vent (commonly referred to as the "submarine") which was formerly used for the incineration of slightly contaminated animal carcasses. This site was put into use in 1955 and has received solid wastes consisting almost exclusively of ^{90}Sr.

Twelve small plots ($\sim$50 square feet each) located southeast of the 141-L Building (southwest corner of 100-F) were used for growing cereal grains, alfalfa, and other crops and contained accurately known amounts of ^{90}Sr and ^{137}Cs. These plots are enclosed by a hardware-cloth fence.

The 120 Building (P-11 Project) served as a laboratory for plutonium criticality studies prior to 1952. A criticality on November 16, 1951, caused extensive plutonium contamination to be spread throughout the building. On December 4, 1951, a fire broke out during the final stages of cleanup of the plutonium contamination and the fire-fighting efforts spread a small amount of plutonium outside the building near the southwest corner. Essentially all of the plutonium contamination has been

9 2 1 2 5 0 1 1 0 3

stabilized with concrete or soil. In addition, there is a 10'x10' crib which lies about 125 feet east of the 120 Building. Core samples taken from this crib revealed no measurable plutonium.

The Biology leach trenches in the 300 Area consist of two 60'x40' trenches which received animal wastes (all ^{90}Sr) from the 331-A and B facilities from October 1967 to December 1968. The trenches are located east of the 331 Building and have been backfilled. New leach trenches for the biology facility complex were put into service in February 1971. These trenches are located about 100 yards southeast of the retired trenches and have not yet received any measurably contaminated waste.

The earth mound west of 300 Area is adjacent to and immediately east of the 300-W Equipment Storage Yard. It was erected around 1952 with dirt removed from an excavation inside the 313 Building and was to serve as a "blast shield" for any explosions which might result from solvent storage in the Equipment Storage Yard. Since the dirt was removed from the 313 Building, it was slightly contaminated with uranium.

Table II

Listed below are PNL Facilities which have no record of unplanned solid or liquid waste releases which would have contaminated the soil surrounding the building. Administrative-type buildings such as the library have not been included in this list.

300 Area		100-F Area
305-B	3705	108-F
314	3706	141-H
318	3714	144-F
320	3730	1707-F
329	3731	1707-FA
330	3745	
331	3745-A	
	3745-B	

Table III

Listed below are presently and formerly assigned PNL Facilities for which routine liquid and solid waste releases are reported by ARHCO, which will also report any unplanned releases from these facilities.

200-E Area	200-W Area	
242-B	222-U	221-T
	292-U	277-T
209-E	2707-U	292-T
2718-E		
		231-Z

UNITED NUCLEAR INDUSTRIES, INC.

Memorandum

To: J. J. Dorian

Date: August 10, 1981

V. R. Richards

From: V. R. Richards

Subject: RADIOLOGICAL CHARACTERIZATION OF THE 100-F AREA ANIMAL LEACH TRENCH (116-F-9) AND THE SAWDUST PIT (118-F-5)

The Animal Leach Trench and the Sawdust Pit were part of the old Battelle biology facilities and were used to dispose of low-level radioactive animal wastes. These facilities were not included in the scope of the "Radiological Characterization of the Retired 100 Areas," UNI-946, because they were still in use by Battelle Northwest Laboratories.

Radiological characterization of these facilities was initiated in August, 1979 and resulted in establishing the radionuclides involved, their concentrations, and an estimate of the total radioactive inventory of their respective contaminated soil columns.

A conventional cable well drilling rig equipped with a 5" dia. drive barrel was used to obtain soil samples at known depths from predetermined sample hole locations. Six sample holes were drilled in 116-F-9 and five were drilled in 116-F-5. Selected samples were analyzed for gamma emitters using a Ge-Li detector. The U. S. Testing Company did the alpha and beta analysis.

The total estimated radioactive inventory of the 116-F-9 (Animal Leach Trench) contaminated soil column is 4.1 Curies (see Table 2). The concentrations of the radionuclides involved are shown in Table 1 and the sample locations are shown in Figure 1.

Battelle Sawdust Pit: Because of time limitations, (end of fiscal year funds) the characterization effort for 118-F-5 was limited to 5 sample test holes for a relatively large designated crib area (450' x 250').

Several samples from two of these test holes indicated contaminated fine sand and sawdust (150 to 700 c/m) at about 6 to 7' below fill grade. Samples from other test holes showed no indication of radioactive contamination.

J. J. Dorian
Page 2
August 10, 1981

The GM probe used to show the radioactive profile of the sample holes detected a narrow band of activity (600 to 800 c/m) and was less than 10" wide in both holes. Concentrations of radionuclides involved are indicated below and the test hole locations are shown in Figure 2.

Radionuclide	Maximum Concentration (pCi/gram)	Minimum Concentration (pCi/gram)
Co-60	5.3E-1	4.7E-1
Sr-90	2.0E2	1.7E1
Pu-239/240	2.1E-1	2.1E-1

Note: Because of the relatively large designated crib area and the limited time available for locating and establishing the actual crib area, I feel an estimate of the total radioactive inventory involved would be a rough guess. My educated guess would be 2 to 4 Curies.

VRR/cmj

Attachments

cc: PA Carlson
WG Westover
RA Winship
RK Wahlen
VRR/File/lb

9 2 1 2 5 0 1 1 0 6

TABLE 1

116-F-9

Animal Leach Trench

Concentrations in pCi/gram

SAMPLE NUMBER	Cs-137	Co-60	Eu-152	Eu-154	Eu-155	Sr-90	Pu-238	Pu-239/240	GM CPM
116-F-9									
A-5	*	*	*	*	*	**	**	**	Background
A-10	*	*	*	*	*	**	**	**	Background
A-15	*	*	*	*	*	1.1E2	*	2.2E-1	180
A17.5	7.8E-1	1.5E0	5.5E-1	*	*	**	**	**	120
A-20	2.9E0	1.2E1	7.9E0	*	*	**	**	**	130
A-22.5	2.8E0	2.7E1	2.5E1	6.8E0	8.6E-1	9.3E1	*	2.1E-1	230
A-25	3.2E0	1.9E1	3.1E1	7.4E0	*	**	**	**	120
A-27	2.2E0	1.5E0	2.4E0	*	*	2.8E1	*	5.5E-2	120
B-20	1.1E0	7.4E0	3.3E0	*	*	4.9E1	*	6.9E-2	200
F-20	*	*	*	*	*	**	**	**	Background
F-25	*	*	*	*	*	5.2E0	*	*	Background
F-30	*	2.5E-1	*	*	*	3.4E0	*	*	Background

*Not Detected
**Not Requested

Note: F sample hole is 20' outside east edge of trench.

TABLE 2

116-F-9

ANIMAL LEACH TRENCH

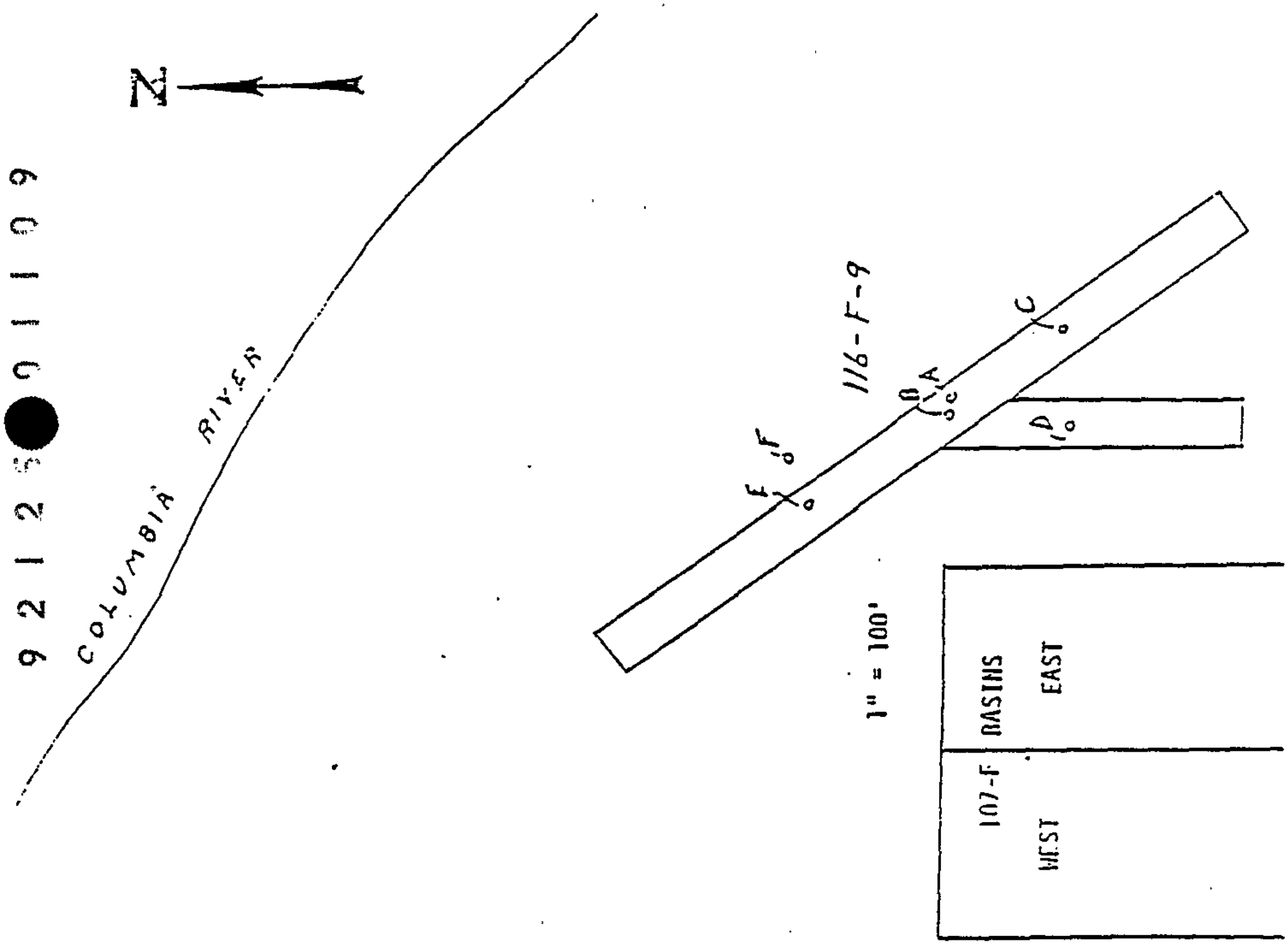
POTENTIALLY CONTAMINATED SOIL COLUMN

Volume = 50,000 ft^3
Mass = 5.0E10 grams

Radionuclide	Ave. pCi/gram	Curies
Cs-137	2.2E0	1.1E-1
Co-60	1.1E1	5.5E-1
Eu-152	1.2E1	6.0E-1
Eu-154	7.1E0	3.6E-1
Eu-155	8.6E-1	4.3E-2
Sr-90	4.8E1	2.4E0
Pu-239/240	1.4E-1	7.0E-3
	Total Curies =	4.1

FIGURE I

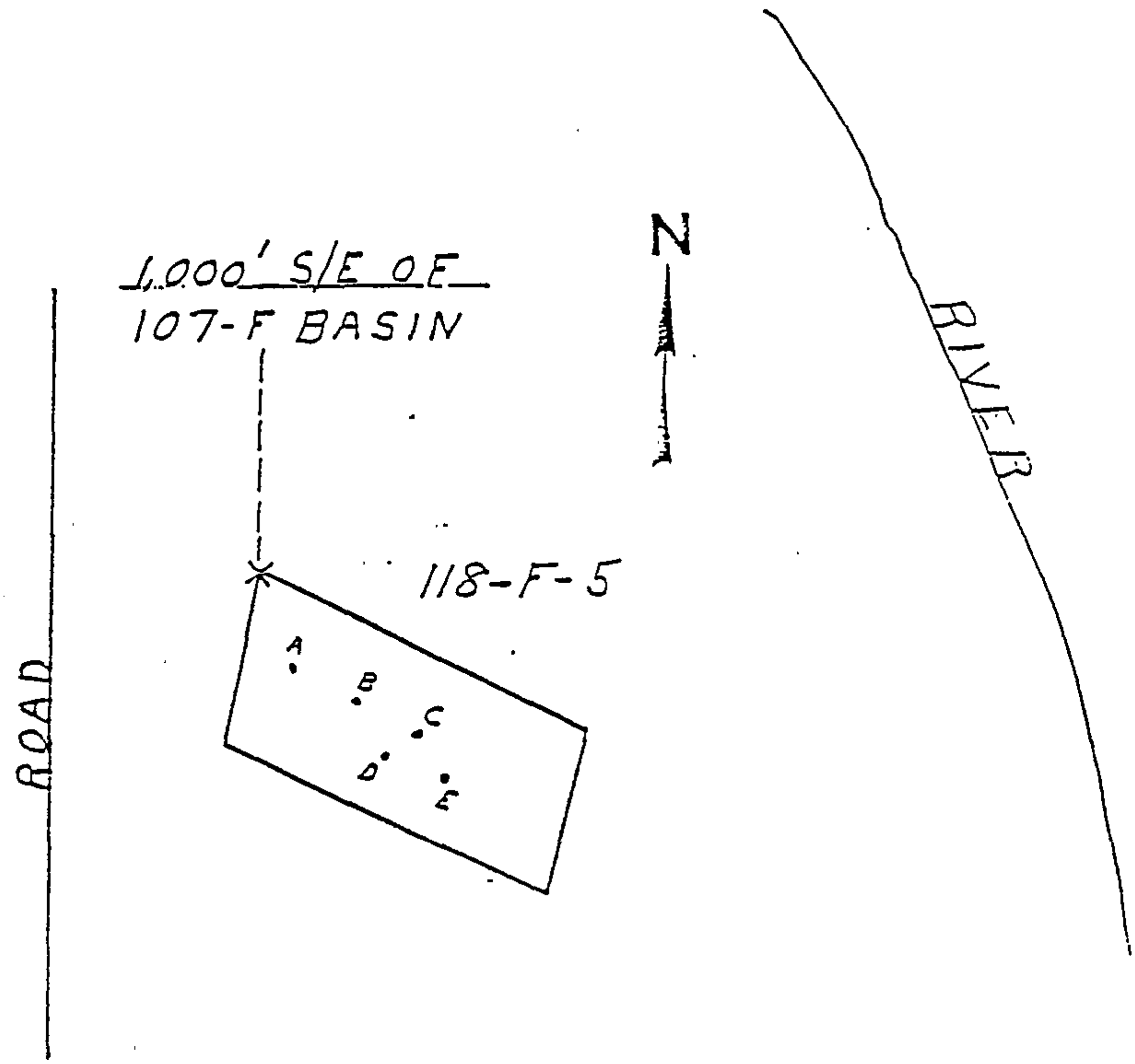
116-F-9 ANIMAL WASTE LEACH TRENCH



9212501109

FIGURE 2

118-F-5 BATTELLE SAWDUST PIT



APPENDIX E

GLOSSARY

APPENDIX E

GLOSSARY

CASK - Special container for handling or shipping high-dose-rate materials.

CLADDING - A "skin" or covering around reactor fuel pieces, poison, P-10 pieces, and all special test pieces.

CROSSHEADER - Pipe that connects to main coolant supply to provide coolant to designated process tubes (always sections of two rows).

GUNBARREL - Steel tube used to support the process tubes and provide a gas seal at the penetrations to the reactor block.

HORIZONTAL CONTROL ROD (HCR) - Used to control the nuclear reaction in the reactor.

"J" METAL SHIPPING CASKS - Special shipping containers designed to safely ship "J" fuel elements in which a high percent of enriched uranium is alloyed with aluminum.

LEAD-CADMIUM ELEMENT - Rod-shaped, 6-in. long piece with aluminum cover used to absorb neutrons in the process tube.

NOZZLE - Capped opening to the process tubes for fuel loading and unloading.

PIGTAIL - Small, pigtail-like pipe connection for cooling flow to the process tubes.

POISON - Any nonfissionable element in a reactor with appreciable neutron absorption cross-section.

PROCESS TUBES - Aluminum or zirconium tubes through the reactor core that carry the fuel column and coolant.

SILICA GEL - Desiccant used to dry gases that circulated through the reactor.

SPACERS - Cylindrical pieces used to center the fuel in the process tube and prevent fuel elements from flushing to the rear during reactor operation.

SPLINES - Flat strips of aluminum and boron used to shape the active section of the reactor, or flatten (distribute evenly) or control the neutron flux in the reactor.

THIMBLE (rod channel thimble, rod thimble) - Sealed aluminum tubes that ran through the graphite to maintain the gas seal in the vertical safety rod and horizontal control rod channels. Vertical thimbles were designed to contain liquid boron if a 3X system was used.

TRANSIENTS - Changing conditions in time that are associated with changes in power level from one steady state to another.

VENTURI - A machined flow-control orifice between the nozzle and the pigtail that provided access for a flow measurement sensing line.

VERTICAL SAFETY ROD (VSR) - Vertically suspended rod that would drop into the reactor if released for a gravity safety system.

3X BALL - Boron balls that were used for emergency backup to shut down the reactor, and therefore functioned as a third backup safety system when they were dropped into the vertical rod channels.

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